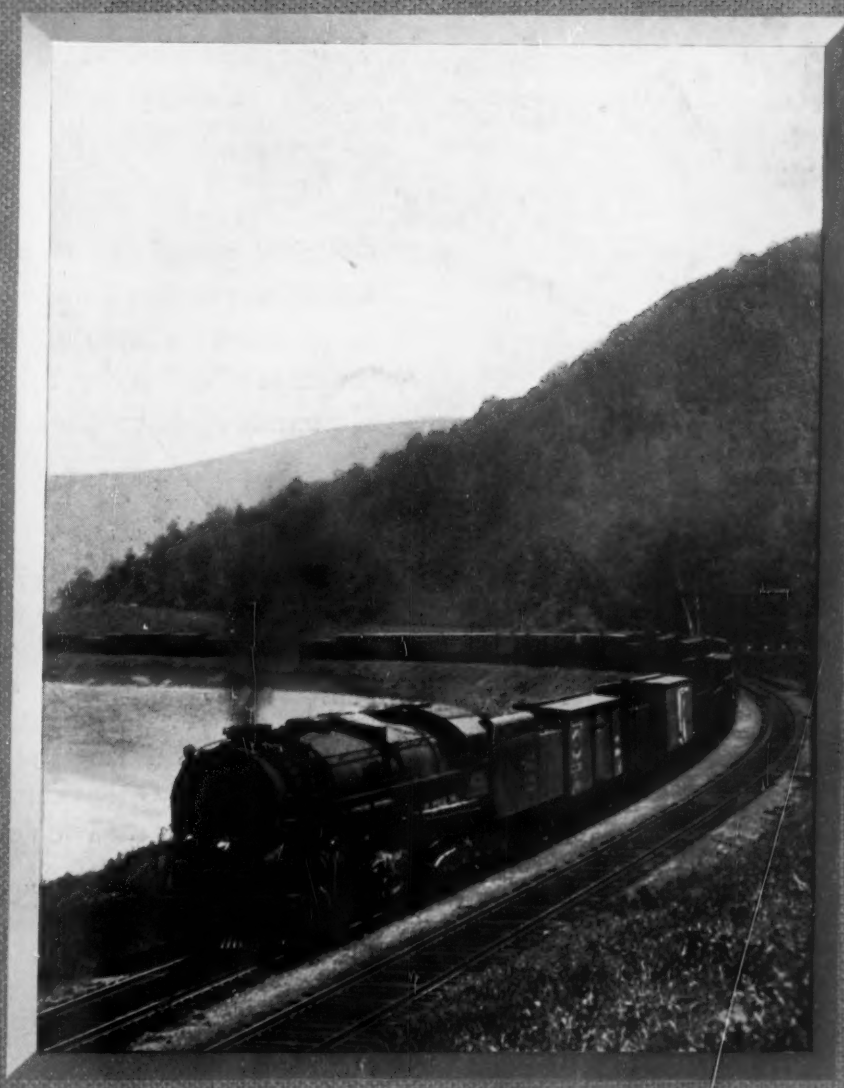
THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED



MASSACHUSETTS
INSTITUTE OF
TECHNOLOGY

VOLUME X, NO. 1
FEBRUARY, 1929

1800 LB. Pressure

1800 pound steam pressure for an installation which will be the largest high pressure steam plant in the world.

700 per cent Rating

700 percent rating—carried on a unit comprising a Ladd Boiler, C-E Fin Furnace, C-E Air Preheater and Lopulco Pulverized Fuel System.

660,000 LBS. per hour

660,000 pounds of steam per hour from one unit—and, work in progress on three units each capable of delivering 800,000 pounds of steam per hour.

... *these are outstanding accomplishments*

THE ability to offer to Industry a service which is not available elsewhere—is responsible for these striking accomplishments.

Complete fuel burning and steam generating units of coordinated design to meet exactly the individual plant need—comprising boiler, stoker or pulverized fuel equipment, furnace, superheater and air preheater—are sold under One Contract, One Responsibility and one set of guarantees.

Our General Condensed Catalog briefly describes Combustion Engineering Corporation equipment. May we send you a copy?

COMBUSTION ENGINEERING CORPORATION

International Combustion Building — 200 Madison Ave., New York

A Subsidiary of
INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

COMBUSTION ENGINEERING

5 POINT PIPE

The "Ins and Outs" of Endurance

Into a flame-filled furnace go pure pig iron and silicious slag, there to be stirred and kneaded together —*puddled*—until every inmost particle of the iron gets a rust-proof slag coating.

Out of the puddling furnace comes a pipe material so staunch, so enduring, that it serves faithfully for generations—this is Reading Genuine Puddled Wrought Iron!

Time has shown no substitute for the puddling process in making pipe that lasts from three to five times as long as ordinary pipe, defying corrosion down the years. For true economy, when you are responsible for construction or maintenance, insist on time-tested, genuine *puddled* wrought iron pipe—and look for the Reading name and spiral knurl mark that identify every piece of Reading 5 point pipe.

1
Resists Corrosion—the puddling process* coats every inmost particle of Reading Pipe with age-lasting silicious slag.

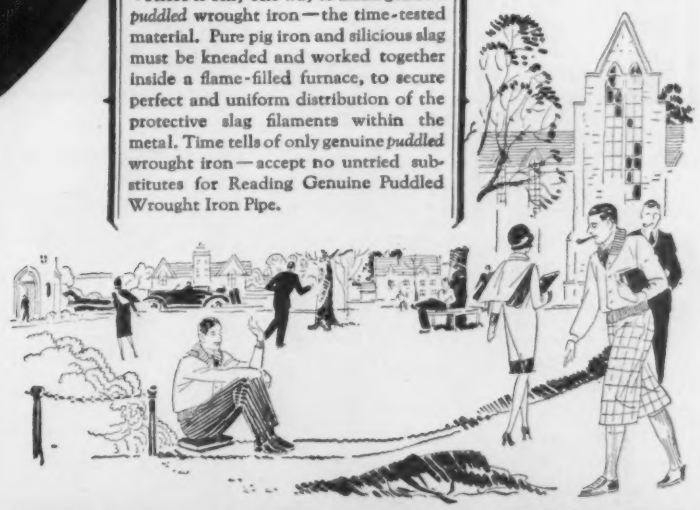
2
Defies Vibration—puddling imparts a tough, rope-like structure that does not crystallize or fracture sharply.

3
Threads Better—clean threads are quickly cut, insuring tight joints that stay leak-proof.

4
Welds Easily—pipe walls have maximum strength; no "weak spots".

5
Holds Coatings Permanently—due to the texture of genuine puddled wrought iron, galvanizing adheres to Reading Pipe four times more thickly than to any other ferrous pipe material. Paint and other coatings last indefinitely.

*There is only one way to make genuine *puddled* wrought iron—the time-tested material. Pure pig iron and silicious slag must be kneaded and worked together inside a flame-filled furnace, to secure perfect and uniform distribution of the protective slag filaments within the metal. Time tells of only genuine *puddled* wrought iron—accept no untried substitutes for Reading Genuine Puddled Wrought Iron Pipe.



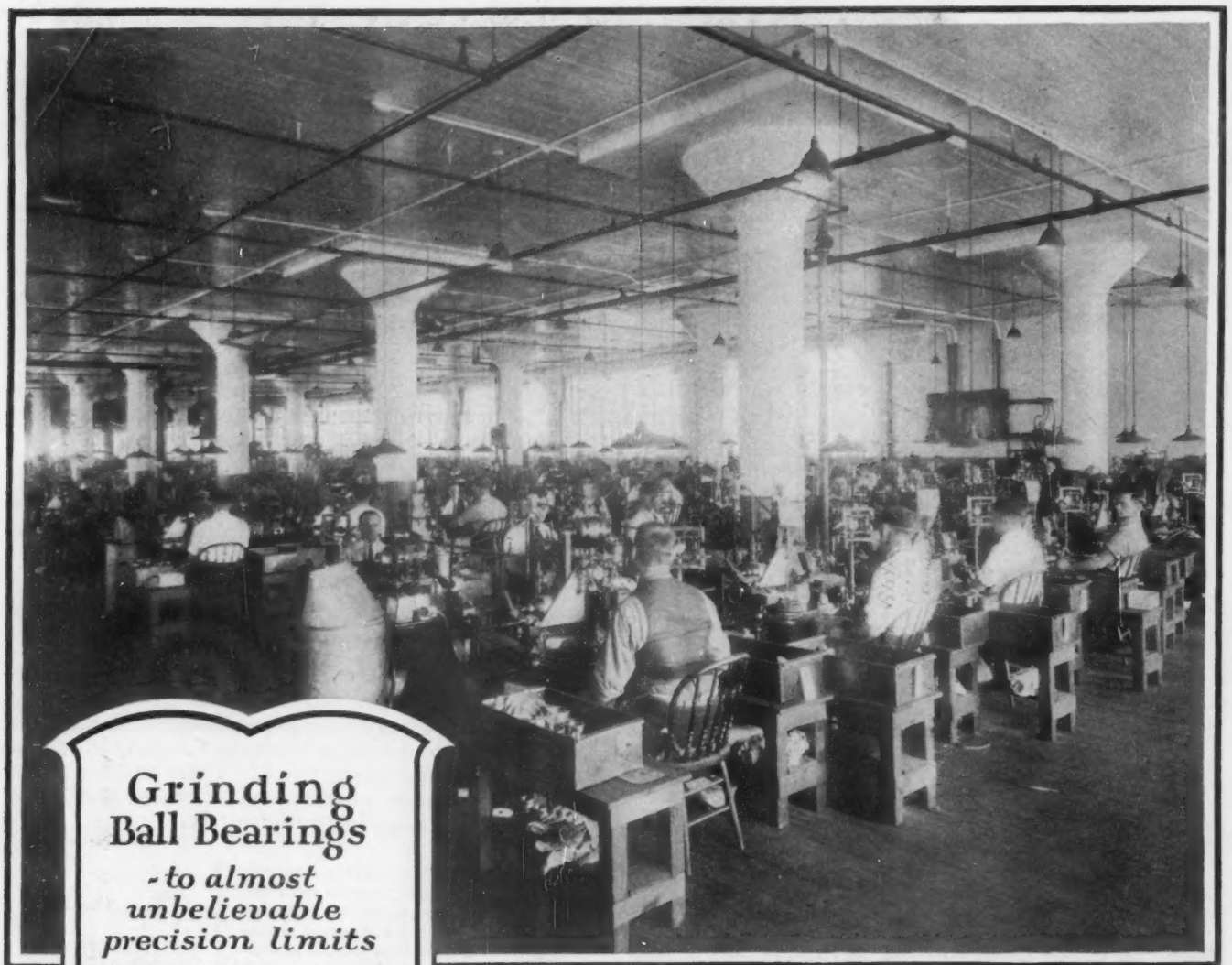
READING '29 ®

READING PIPE

GENUINE PUDDLED WROUGHT IRON

READING IRON COMPANY, Reading, Pennsylvania

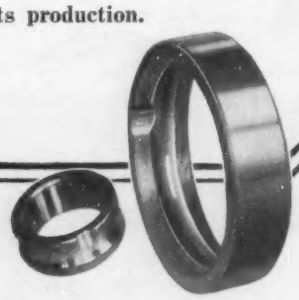
Atlanta	Buffalo	Detroit	New York	St. Louis	Fort Worth
Baltimore	Chicago	Houston	Pittsburgh	Tulsa	Seattle
Boston	Cincinnati	Los Angeles	Cleveland	San Francisco	Philadelphia



Grinding Ball Bearings

- to almost unbelievable precision limits

IT may be human to err, but error has no place in the New Departure plant. Human ingenuity has circumvented error by all but eliminating the human element and by putting its trust in machinery — superhuman in the uniform accuracy of its production.



THE superiority of the ball bearing over other forms of anti-friction devices is built on its marvelous accuracy of manufacture—the exquisite precision of every part.

The final steps in the fabrication of New Departure Ball Bearings are the grinding and lapping operations. The raceways are finished mirror-smooth, precise in eccentricity, diameter and curvature to almost unbelievable limits, by exclusive methods.

One fact can be divulged, however. The smoothness and accuracy of the grinding is accomplished partly by the use of spindles mounted on New Departures—"turning up" as high as 30,000 R. P. M.

New Departure Ball Bearing precision lends permanent precision to the machinery which it supports. Fifty million a year are used to banish the excessive maintenance costs of friction, wear and lost power.

NEW DEPARTURE

BALL BEARINGS

1160

LEAD goes down to the sea in every ship that is built. Lead-base bearing metals support the shafts of propulsion and auxiliary machinery. Red lead and blue lead paints protect the hull and all metal on board from the corrosive action of salt water. And white lead paint protects and beautifies the woodwork. On land, too, paints with the highest lead content give the most enduring protection to all surfaces, outside or inside. Lead and zinc flow sheets are available *free* —also other valuable data on lead and its products, for class room use. Write *The Eagle-Picher Lead Company, 134 North La Salle Street, Chicago.* Eleven plants. Branches in all principal cities.

E A G L E - P I C H E R

Producers of Lead and Allied Products

PAVERS

MIXERS

PNEUMATICS

Ransome CENTRAL MIXING PLANTS

CHUTES~

More Ransome Mixers are found in Central Mixing Plants than any other make.

The following Central Mixing Plant concerns have selected Ransome Mixers.

P. Flanigan & Son, Baltimore, Md. One—1 yd. mixer.
Chas. H. Fry Constuction Company, Erie, Pa One—1 yd. mixer.
Ready Mixed Concrete Co. Pittsburgh, Pa. Two—3 yd. mixers.
General Material Company, St. Louis, Mo. Three—2 yd. mixers.
Hankins-Paulson Company, Uniontown, Pa. One—1 yd. mixer.
Ready Mixed Concrete Co., Kansas City, Mo. Three—2 yd. mixers.
McClain Sand Co., Morgantown, W. Va. One—1 yd. mixer.
Charles Warner Co., Philadelphia, Pa. Two—1½ yd. mixers.
Ready Mixed Concrete Corp., New York City One—3 yd. mixer and one 1½ yd. mixer.
The Van Sciver Corp., Philadelphia, Pa. Two—2 yd. mixers.
Ready Mixed Concrete Corp., Richmond, Va. One—2 yd. mixer.
Super Concrete Corp., Washington, D. C. One—3 yd. mixer.
Jahncke Service, Inc., New Orleans, La. One—1 yd. mixer.
Caldwell Construction Co., Charlotte, N. C. One—1 yd. mixer.
John P. Callaghan, Inc., Newark, N. J. One—1½ yd. mixer.
Big Rock Stone & Material Co., Little Rock, Ark. One—2 yd. mixer.
Avril Tru-Batch Concrete, Inc., Cincinnati, Ohio. One—2 yd. mixer.
Wet Mixed Concrete Co., St. Louis, Mo. Two—2 yd. mixers

MIXERS

STEEL TOWERS

TILTING MIXERS

If you haven't read "A Survey of Central Mixing Plants" send us $1.50 before the limited edition is exhausted.

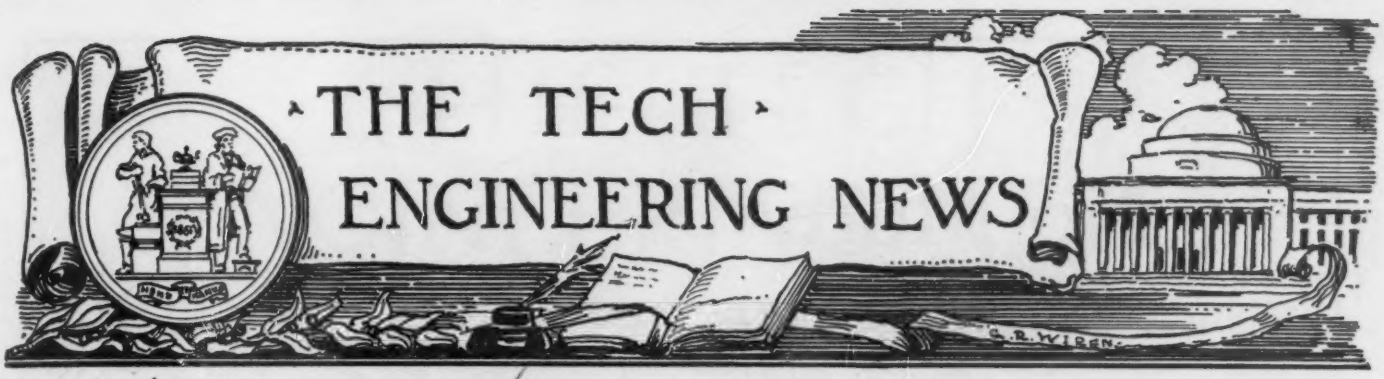
PAVERS

Central Mixing Plant owned by J. P. Callaghan, Inc., Newark, New Jersey, containing a Ransome 1½ yd. mixer.

Ransome Concrete Machinery Company

1850—Service for 79 Years—1929

Dunellen New Jersey



Volume X | CAMBRIDGE, MASS., FEBRUARY, 1929 | Number 1

Copyright 1929 by The Tech Engineering News

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer co-operation between Alumni and undergraduates.

THE MANAGING BOARD

HOWARD S. GARDNER, JR. '30 — *Editor*
CHARLES C. LADD '30 — *General Manager*
CHARLES F. EDLUND '30 — *Business Manager*
IRVIN R. MITCHELL '31 — *Managing Editor*
CHARLES R. WOOD '31 — *Publicity Manager*
NELSON B. HASKELL '31 — *Advertising Manager*
RICHARD T. KROPF '31 — *Circulation Manager*
CHRISTIAN E. GROSSER '31 — *Associate Editor*
ANTHONY R. SAVINA '30 — *Treasurer*

EDITORIAL DEPARTMENT

HOWARD A. ROBINSON '30 . . . . . *Assistant Editor*
JOHN H. DODGE, JR. '31 . . . . . *Features Editor*

EDITORIAL STAFF

E. H. ANDERSON '32
C. CHAYABONGSE '32
R. C. N. CALVERT '32
N. D. FITZGERALD '31
T. HARPER '32
I. W. HILLIARD '32
H. G. PROTZE '32
C. W. RANKIN '31
W. F. SPREEN '32
A. G. STOCKWELL '32

BUSINESS DEPARTMENT

GEORGE M. ORNE '31 . . . *Assistant Circulation Manager*
HERBERT E. RAYMOND, JR. '31 . . *Assistant Treasurer*

BUSINESS STAFF

A. D. BERTOLETT '31
F. S. CHAPLIN '32
H. E. CLEMENTS '32
D. W. BROOKFIELD '32
S. EDELSTEIN '32
K. J. HEINICKE '32
G. D. JOHNSON '32
J. E. LINZ '32
A. M. MAGUIRE '32
P. P. SHELBY '32
R. M. STEWART '32
E. A. NEWCOMB '32

THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

Chairman, Mr. Willard V. Merrihue, 1 River Road, Schenectady, N.Y.

The Transit
Iowa Engineer
Colorado Engineer
Nebraska Blue Print
Pennsylvania Triangle
Sibley Journal of Engineering
Purdue Engineer
Rose Technic
Michigan Technic
Ohio State Engineer
The Tech Engineering News
Wisconsin Engineer
Penn State Engineer
Technograph
Cornell Civil Engineer
Minnesota Techno-Log
Kansas State Engineer
Kansas Engineer
Princeton E. A. News Letter
Armour Engineer
Oregon State Technical Record

SUBSCRIPTION PER YEAR, $1.50
Address all communications to The Tech Engineering News, Walker Memorial, Cambridge 39, Massachusetts. Telephone, University 6864
Advertising rates upon application

TABLE OF CONTENTS

	Page
IDEAS OF AN INVENTOR. By Georges Claude	7
AUTOMATIC TRAIN CONTROL. By John B. Babcock '10	9
MODERN FREIGHT TRANSPORTATION. By Lawrence Richardson	12
MOTIVE POWER DEVELOPMENTS	14
EDITORIALS	17
THE ENGINEERING FIELD	18
DEPARTMENTAL NOTES	20
BOOK REVIEWS	22

No More Checks From Home

IN the not so distant future, a time is coming when the check from home will be only a fond memory. You probably look forward to those days with mingled feelings. You welcome the idea of being on your own, knowing that money *earned* is doubly satisfactory for it represents accomplishment.

Contrary to popular conception, you'll find that not all business men are exclusively interested in dollars and cents. You'll quickly distinguish between the narrow and the broad viewpoint in business just as you do today in college.

Stone & Webster, Inc., has gathered an organization of men whose breadth of vision, whose ideals of service, whose ability are recognized in all business and professional fields. No matter what profession or business you choose, you'll meet Stone & Webster men—financing utilities, operating gas, electric and transportation companies, building power and industrial plants. They're wide awake, alert, progressive. You'll find the Stone & Webster organization is worth knowing and worth doing business with.

STONE & WEBSTER
INCORPORATED

OPERATE FINANCE BUILD

©CIB 18269

FEB 27 1929

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME X | FEBRUARY, 1929 | NUMBER 1

Ideas of An Inventor

The fundamental principles underlying success in research and invention

By GEORGES CLAUDE
Member of the French Academy of Sciences

THERE are many persons who believe that the more science advances and the more industry progresses, the less there remains to be invented. On the contrary, every new resource, every new invention is able to combine with some of the other existing possibilities to permit many other combinations. This is not a question of opinion or feeling, it is an absolute, mathematical certainty; so that contrary to the opinion just mentioned, we ought to believe that our power of realization increases constantly, quickly and indefinitely — the rapidity of modern progress is nothing other than the confirmation of this fact. Such a positive fact may certainly make us proud of our science. How wrong we should be, however, to forget our dependence of the admirable variety of the properties of matter and energy. Far from being creators in the sublime sense of the word, we are but the simple utilizers, the simple workmen of these properties. Science, rather than boasting of knowing the last word of things, feels stronger every day that the little it knows is little indeed, before the infinite of all that it ignores. The first duty of science and scientists of today, indeed, is to be modest and respectful of everybody's beliefs, and such is the feeling expressed by the great majority of the members of the French Academy of Sciences in a recent inquiry on "Le sentiment religieux et la Science."

But if the first need of an inventor is an absolute and solid confidence in the innumerable resources placed at his disposal by nature and science, it does not follow that he can use them without discrimination. Getting the result needed from a thing or a substance poorly fitted for that purpose is no longer worthy of science, when it is probable that far better things or substances or combinations can be found to suit that purpose in the immense and ever growing arsenal of the properties of matter and energy. In that respect, we may venture to say that it is probably heresy for us to do a single thing now as it was done a century ago.

The name of Dr. Claude is not strange to the majority of our readers. His successes in research and invention have placed him among the most distinguished scientists of our time. For the benefit of those, however, who are not familiar with his works we may mention a few of his most important contributions to science and industry. Among these are a process for liquefying air, a process for fixation of nitrogen, the discovery of acetone as a solvent of acetylene, and the invention of the Claude neon light tube. His article is substantially the same as his address delivered at the Second International Conference on Bituminous Coal held in Pittsburgh on November 19, 1928, and here at the Institute on November 27. We feel great satisfaction in being able to make it available to such an increased number over the limited few who were privileged to hear him on these occasions.

It follows from all this that, in my opinion, the difficulty of an inventor is not to make an invention, but to choose from among the multitude of inventive ideas which strike his mind the one which is really worth while. This is all the more so since the achievement of a small invention frequently proves to be as difficult as that of a greater one.

It follows also that we must never despair because of the difficulties we inevitably meet in the study of such a problem; for we may be sure that means always exist with which they may be overcome.

It follows, further, that for any problem a simple solution only is worth considering.

I spoke about my inclination for subjects of note. It led me to another more questionable conclusion. A rule to which I tie my mind — the best I can, for an inventor's mind is a fiery steed which often leads its master where he would prefer not to go — is to stray from the usual paths, in the simple belief that the less frequented is the way, the greater are the chances of meeting unknown and important things. This, of course, is not invariably true; many times interesting inventions are made in the most explored fields. But the probability, of course, of making important discoveries is better in less explored regions.

I agree that this way is not without some serious drawbacks. It may happen, for instance, that proceeding along a new road one may make such an advance as compared to that which has been done before, that the result obtained does not correspond to an existing need, or even appears so fantastic to those engaged in ordinary pursuits that one is kindly advised to take a rest in some lunatic asylum. If you are inclined to find in these friendly remarks excitement and pleasure rather than discouragement, then, all is for the best.

These unexplored regions border generally on the last chapters of science

which explains why, for instance, as soon as acetylene became industrial, my friend Hess and I took an interest in that new question from whence resulted our invention of dissolved acetylene.

Likewise, as soon as the low temperature became industrial, thanks to Linde's work, I threw myself into that subject, from whence resulted my inventions on liquid air, oxygen and nitrogen.

Liquid air in its turn led me to the domain of rare gases, in which I was the first industrial explorer, and from which neon lighting resulted. It led me also to water and coke oven gas liquefaction and from there to synthesis of ammonia by my personal technique of hyperpressures.

In these different inventions, of course, my confidence in the innumerable resources at our disposal has had many occasions to exert itself. Very often it has been the only reason for my going into a new question.

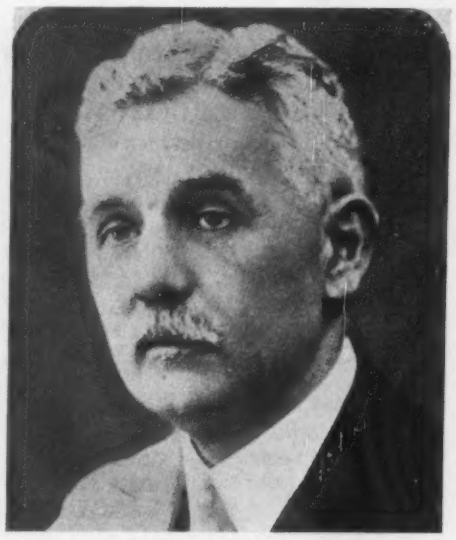
Such was the case with the dissolved acetylene industry that I started in 1896 with my friend Hess. The only reason for this invention was our conviction that if we could discover a convenient solvent by dissolving acetylene in it under pressure we would procure for its storing the same advantages as by its liquefaction; moreover, its dilution in an inert liquid would do away with the terrible explosibility of liquid acetylene, which ruined the hopes of the illustrious R. Pictet. Thus we discovered the remarkable solvent properties of acetone and its efficiency in removing the explosive properties of acetylene. I remember, as one of my best souvenirs, my joy in examining the Seltzer water siphon filled with a solution of acetylene in acetone under five atmospheres, and in which glittered quietly a thread of platinum reddened by an electric current. Note that in spite of my confidence in the result, it was from some hundred yards and through an opera glass that I enjoyed that sight.

I take pleasure in noticing that in spite of immense quantities of dissolved acetylene now manufactured, the formula we gave twenty-two years ago is always used; and the liquid used is always the one we chose among thousands and thousands, namely, acetone.

It was the same confidence in our resources which led me to the liquid air industry.

It is well known that practically the only source of cold used to bring air to liquefaction is the expansion of compressed air. But we can expand it without external work, that is, by a simple tap, or with external work, by causing compressed air to move a motor. This second method is of course better, since it allows us to remove more energy from expanding air, thus cooling it further. Why, then, did Linde prefer the first method? Because the expansion machine cooling excessively, the lubricant used will freeze and block the machine: "One cannot therefore," affirms Linde, "reach such a result by such a method."

At the reading of the Linde pamphlet I started. "How is that?" I asked myself. "The lubricant will freeze? If it is freezable, yes; but if it is not, it will not freeze, I suppose! And the machine will turn." On only this rather elementary remark, moved by this hope, I undertook to find out among all the liquids of chemistry the one which would suit my purpose. Soon petroleum ether revealed its properties to me, and the machine worked. Of the supposedly insurmountable ob-



M. GEORGES CLAUDE
The author of "Ideas of an Inventor"

stacle which stopped Linde, nothing, absolutely nothing, remained for me.

Now we may almost affirm that it is always the same: when a thing is theoretically possible, when only practical difficulties prevent it from being achieved, we may be assured that these difficulties are not insurmountable; and that at the cost of more or less time and labor an artifice will be found to solve the difficulties and to give satisfaction to theory.

It is amusing that petroleum ether itself is, in fact, useless for the operation of liquid air machines, as I soon discovered. So energetic is the effect of the expansion that the cooling is very rapid and after a few minutes the liquid air itself produced in the machine is all that is needed for its lubrication. So that the bar which so completely stopped Linde in that way was in reality but a shadow and petroleum ether was only the opportunity for me to bring my effort to this marvelous question.

It is curious to notice the important role played by these questions of lubrication in my career. Another example occurred in 1916 when Germany opened the war of gases against the French. During some days it was believed that all was lost and that under the waves of chlorine our lines would be carried away. It was a question of life and death to answer the attack. Unfortunately, neither in England nor in France did we know how to liquefy the indispensable chlorine. This gas, however, is one of those that liquefies at a very moderate pressure, but the difficulty came from the virulence with which wet chlorine attacks metals. It is not possible, therefore, to liquefy chlorine with ordinary compressors, which, furthermore, it would not be possible to lubricate, owing to the fact that oils and greases are likewise destroyed by chlorine. Such was at least the belief of chemists, and it appeared very sensible. Before the war, however, I had to consider the question and one day an idea jumped into my brain, as often happens. I knew that dry chlorine does not attack metals. I knew that concentrated sulphuric acid does not attack them either. I knew that sulphuric acid, in addition to its drying properties, possesses lubricating qualities which is fully attested by its old name of vitriol oil. I knew, at last, that this oil is not attacked by chlorine. Putting this and that together, the idea came to me to liquefy chlorine in ordinary compressors lubricated by sulphuric acid which would at the same time oil the compressor and maintain the perfect dryness of chlorine. I had abandoned the idea because of lack of time and suddenly circumstances gave to the success or failure of this idea a tragic interest. I made the test; the test succeeded. From that minute liquefying chlorine became as easy as liquefying sulphurous acid and soon tons and tons of liquefied chlorine came to the help of our soldiers. And, I repeat, that is always the same. Find out in every case, among the innumerable properties of matter, the only one really fitted to the difficulty, apply it, odd as it may be, and the difficulty fades away.

It is well known that air is no longer the simple mixture of oxygen and nitrogen our fathers supposed. The wonderful work of Ramsay showed it to contain the most extraordinary collection of strange gases, that is, the rare gases. Confident that some day their remarkable properties would assure them important applications, I planned to put them at the disposal of science and industry. For that purpose, instead of getting these gases by the extremely expensive treatment of

(*Continued on page 24*)

Automatic Train Control

The protection of twenty thousand miles of track in the United States by automatic devices

By JOHN B. BABCOCK '10
Professor of Railway Engineering
Massachusetts Institute of Technology

AS a result of Order 13413 of the Interstate Commerce Commission, automatic train control has become a reality on the railroads of the United States. Today more than 8,000 locomotives and 20,000 miles of track are equipped with automatic stop or train control devices. Although the percentage of track mileage so equipped is small, it is significant that nearly 20 per cent of the locomotives used in road service are now operated under automatic control. In addition to installations on 15,000 miles of track made in accordance with I. C. C. requirements, 5,000 miles have been equipped voluntarily by the Southern Railway, the New York Central Lines and the Chicago & Northwestern Railway.

No such rapid development may be expected in the next few years because the Commission has recently announced that it will not require further installations at the present time. The reasons for this decision are important and will be presented later.

Early Developments

Automatic block signals were first used about sixty years ago, their chief purpose then being to ensure safety of train operation by the prevention of collisions, *i.e.*, by *stopping* the trains. As the art of railway signaling has advanced, automatic block signals have become useful as a means of *keeping trains moving* under safe conditions. It is evident that the use of block signals does not remove the "human factor" — those who operate the trains are not infallible. An engineman may still fail to see a signal or may fail to heed it, due to mental aberration, sudden illness, or death. Some form of automatic train stop, which would apply the brakes if the engineman failed to obey the signal, has long been in the minds of inventors, but the railroads gave it little attention.

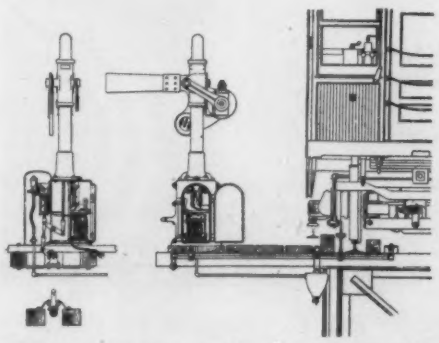


FIG. 1. BOSTON ELEVATED RAILWAY
Original installation of automatic train stop in 1901; in use with certain modifications at present time. (Union Switch & Signal Co.)

The early experimental devices were based on mechanical contact between the wayside apparatus (on the ground) and the brake setting apparatus (on the locomotive). The Vogt automatic train stop of about forty years ago was of this type. It consisted of an extension of the train pipe to the roof of the locomotive cab, terminating in a glass tube or stopcock, and an arm on the signal post which projected out horizontally when the signal was at danger. If an engineman should pass the signal under these conditions, the projecting arm would break the glass tube or open the cock and thus apply the brakes.

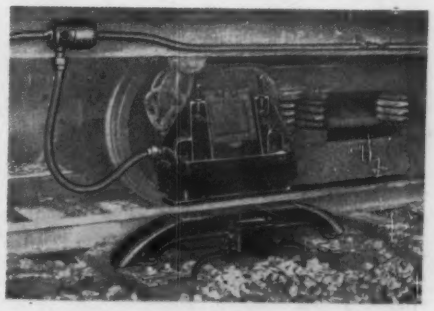


FIG. 2. RECEIVER AND INDUCTOR
Typical installation of intermittent inductive automatic train stop using inert wayside inductor. (General Railway Signal Co.)

The first permanent installation of an automatic train stop was made on the rapid transit lines of the Boston Elevated Railway in 1901. (Fig. 1.) The stop device consists of trip arms near the rail at each signal. When the signal is at danger, the trip arm is in its vertical position extending up high enough to strike an angle cock in the train pipe, thus applying the brakes. With the signal at caution or clear, the trip arm is swung down out of the way. In the first installation the trip arm was operated either by direct mechanical action of the semaphore or by means of a pneumatic cylinder. Subsequent modifications have been made in the method of operation but the basic principle has remained the same. An all-electric or solenoid type of control of the trip arm is now used on their latest installation; this eliminates the cost of installing and maintaining air pipe lines for the sole purpose of the train stop. Similar devices are in use on rapid transit lines in a number of the larger cities.

In 1910 the Hill type of train stop was installed by the Pennsylvania at its New York terminal. Since this was a surface railroad, it was necessary to provide a mechanism on the locomotive which would not cause an application of the brakes in case it struck some obstruction on the track. This was accomplished by having the brake valve on the locomotive and the trip arm on the ground act practically as toothed gears which engage (when in the stop position) as the locomotive passes the trip. The middle tooth of the trip arm actuated the vertical stem and applied the brakes. Any foreign obstructions on the track would be pushed aside by the projecting teeth without engaging the valve stem in the center.

During the period up to the World War, little progress had been made in the application of automatic train stops to steam railroads. One notable exception was the installation of the Miller train control on a 107-mile double track division of the Chicago and Eastern Illinois Railroad. This device, which is of the "ramp" type and electrically controlled, has been in successful operation since 1914.

I. C. C. Orders Train Control

Up to 1920 a number of investigations had been made by governmental boards and by committees of railroad organizations and various devices had been given experimental installations, but little progress had been made. It had been demonstrated, however, that automatic train control was possible, and that there were devices available

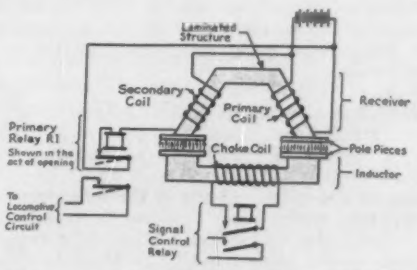


FIG. 3. PRINCIPLES OF CONTROL
Diagram illustrates inductive control from wayside to locomotive in intermittent automatic train stop. (General Railway Signal Co.)

which could be further developed for practical application.

The real motivating influence for the installation of train control is found in the Transportation Act of 1920, the legislation enacted at the time the railroads were returned from Federal control to private operation. This act gave the Interstate Commerce Commission authority to require the installation of automatic train control devices. The Commission acted promptly and on June 13, 1922, issued Order 13413 requiring forty-nine of the larger railroads to equip designated portions of their lines with automatic train stop or train control; and on January 14, 1924, issued a second order requiring additional installations. At the present time these installations are 99 per cent complete.

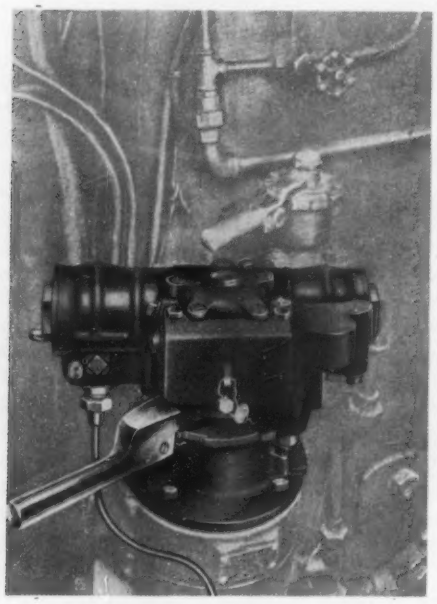


FIG. 4. BRAKE ACTUATOR

This device is applied to engineman's brake valve. When the controlling electro-pneumatic valve is deënergized, the actuator moves the brake valve to service position. (General Railway Signal Co.)

The I. C. C. requirements for automatic train control as stated in the original order, with modification granted on July 18, 1924, are as follows:

Purpose

The purpose of this general specification is to define automatic train stop or train control devices and to outline essential features involved in their design, construction and installation on railroads.

Definition of Automatic Train Stop or Train Control Devices

A system or installation so arranged that its operation will automatically result in either one or the other or both of the following conditions:

First. Automatic Train Stop. The application of the brakes until the train has been brought to a stop.

Second. Automatic Speed Control. The application of the brakes when the speed of the train exceeds a prescribed rate and continued until the speed has been reduced to a predetermined and prescribed rate.

Functions

In prevailing practice the primary function of automatic train stop or train control devices is to enforce obedience to the indications of fixed signals; but the feasible operation of essentially similar devices used without working wayside signals may be regarded as a possibility. The following features may be included, separately or in combination, in automatic train stop or train control systems:

1. Automatic Train Stop

(*a*) Without manual control by the engineman, requiring the train to be stopped; after which the apparatus may be restored to normal condition manually and the train permitted to proceed; or

(*b*) Under control of the engineman, who may, if alert, forestall the application of the brakes by the automatic train stop device and control his train in the normal manner in accordance with hand signals or under limits fixed by train order or prescribed by the operating rules of the company.

(Note: The modification which permits the use of a "forestalling" device was made on July 18, 1924.)

2. Automatic Train Control or Speed Control

(*a*) Automatic stop, after which a train may proceed under low-speed restriction until the apparatus is automatically restored to normal or clear condition by reason of the removal of the condition which caused the stop operation.

(*b*) Low-speed restriction, automatic brake application under control of the engineman who may, if alert, forestall application at a stop indication point or when entering a danger zone and proceed under the prescribed speed limit, until the apparatus is automatically restored to normal or clear condition by reason of the removal of the condition which caused the low-speed restriction.

(*c*) Medium-speed restriction, requiring the speed of a train to be below a prescribed rate when passing a caution signal or when approaching a stop signal or a danger zone in order to forestall an automatic brake application.

(*d*) Maximum-speed restriction, providing for an automatic brake application if the prescribed maximum speed limit is exceeded at any point.

Rapid Progress Since 1922

Improvements in train control devices came rapidly when it was recognized that desultory experiments would no longer satisfy the Commission. Through the coöperation of the railroads, the signal companies and other agencies, such as the American Railway Association, much has been accomplished. None of the installations built under the I. C. C. order are of the same type as those in operation before 1922; which fact shows how rapid the changes have been. In fact, two years after the first order was issued a modification was granted permitting the use of a "forestalling" or "acknowledging" device. This permissive feature has had a far reaching effect on the type of installations finally adopted.

At the time Order 13413 was made, there were three applications of automatic train control in operation on regular road service as follows: Chicago & Eastern Illinois (previously mentioned), Rock Island (C. R. I. & P.) and Chesapeake & Ohio, with a total of 277 track miles and 142 locomotives equipped. These were all of the "ramp" or intermittent electrical contact type.

After considerable experimentation, the conclusion had been reached that the mechanical trip type (as used on electric railway rapid transit lines) was not practical for ordinary open road service on surface tracks, among the objections being the difficulty of constantly maintaining the wayside trip device at the proper relation to the locomotive brake operating attachment, the likelihood of unnecessary automatic brake applications due to obstructions striking the locomotive apparatus, and the effect of snow and ice on the wayside apparatus. For this reason the "ramp" type had been developed, eliminating some of these objectionable features. Since both the C. & E. I. and the Rock Island installations have been accepted by the Commission, a brief description of this system is given.

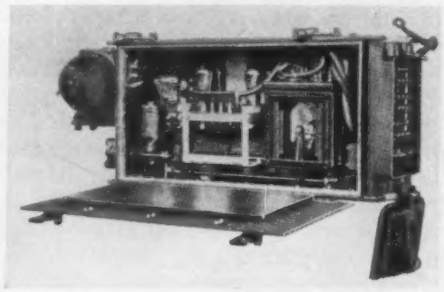


FIG. 5. EQUIPMENT CASE

Typical equipment case for housing train control relay and other electrical apparatus. (Union continuous speed control system.) This case is usually carried on the locomotive, occasionally on the tender.

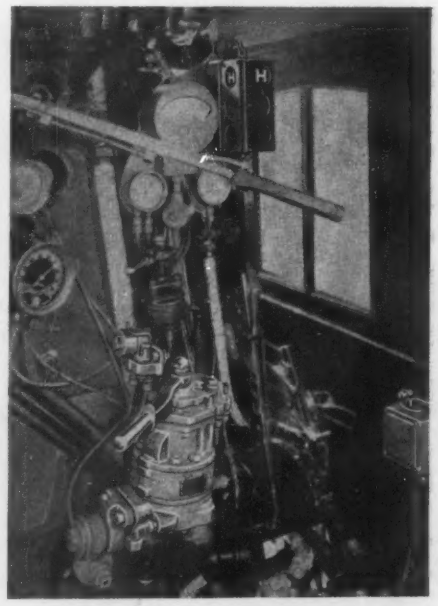


FIG. 6. INTERIOR OF CAB

Showing cab signal, speed indicator, engineman's brake valve, acknowledging lever and cut-out switch. Installation is a Union 3-speed continuous system on Santa Fe. (A. T. & S. F.)

Ramp Type

The wayside apparatus consists of a ramp about eighty feet long, located approximately two feet outside the right hand rail. The ramp is so controlled by the signal circuits that it receives electrical energy when the clear or proceed condition is to be given, and it is deënergized when the indication is "stop." Ramps are located at points where the engineman would ordinarily make a service application of the brakes to bring his train under control to stop at a signal. The locomotive carries a shoe which is lifted up as it travels over the ramp. If the ramp is energized, the shoe receives an electrical impulse which prevents an application of the brakes. When the ramp is deenergized, the shoe fails to receive energy as it passes over the ramp, and a brake application results. This system can be modified so that when a caution (rather than a stop) indication is the proper one to be given, current of a different polarity is present in the ramp which actuates the engine apparatus to the caution position; this provides for speed control.

Train Stop vs. Speed Control

The principle of induction for the control of locomotive apparatus has been adopted on all of the new installations under the I. C. C. order. This is a distinct improvement over the earlier systems as it eliminates the necessity of physical contact between wayside and locomotive apparatus. No single system of automatic train control has met the approval of all the railroads and we find several types now in operation. Train control systems may be classified in two ways, (1) as to the type of control exerted on the train — whether a simple automatic stop or some form of speed control and (2) as to the extent of control on the track — whether it is intermittent, *i.e.*, effective only at certain points, or continuous.

In its requirements, the Commission provided for either automatic stop or speed control, or a combination of them. The primary purpose of automatic train control is to compel obedience to the indications displayed by the signals. The simple automatic stop functions as follows: Whenever the engineman fails to "acknowledge" a signal giving a restrictive indication, an automatic application of the brakes takes place, and the brakes can not be released until a "reset" contactor is operated. This device is usually placed on the tender at a point which can not be reached without getting down from the locomotive, thus ensuring a complete stop. If, however, the engineman operates an acknowledging or forestalling lever, conveniently located by his seat in the cab, when he sees this restrictive indication, an automatic brake application is avoided and he retains full control of the train. The underlying principle is that he has by this acknowledgment shown that *he is alert* and is aware of the caution or danger warning which he has received. Under these conditions he is assumed to be fully capable of controlling the train in accordance with the signal indications and the rules of the company.

Speed control goes a step further and provides not only that he must acknowledge a restrictive indication (failure to do so would result in an automatic stop) but he must bring the train within the speed limit prescribed by the signal indication. For example, if a signal gives a caution indication, speed must be reduced to such an extent that a stop could be made before the next signal is reached, or in case the train enters an occupied block a certain minimum speed limit must be observed. Failure to bring the train speed within the proper limit will result in an automatic brake application but in this case the brakes can be released as soon as the speed has been reduced sufficiently. In all automatic brake applications, a service application is given, but the engineman can always make an emergency stop if necessary.

In the original requirements of the Commission, the permissive feature of "acknowledging" was not included, but it was added in 1924. Several of the roads which were experimenting with speed control systems changed to the plain automatic stop when the I. C. C. requirements were thus modified. At the present time the automatic stop, which is simpler and does not require locomotive apparatus for measuring speed and distance, has been adopted on five-sixths of the mileage on which train control has been installed; automatic stop being used on about 16,500 track miles; and speed control on 3,500 miles.

INSTALLATION OF AUTOMATIC TRAIN STOP OR TRAIN CONTROL DEVICES ON UNITED STATES RAILROADS
JULY 1, 1928

Type	*Miles of road equipped*	*Percentage of total installations*	*Miles of track equipped*	*Percentage of total installations*	*Locomotives*
Intermittent					
Induction (inert wayside element)	6,049.7	54.1	10,910.7	55.5	
Magnetic	1,222.0	10.9	1,427.4	7.3	
Electrical contact (ramp)	478.9	4.3	847.7	4.3	
Total intermittent	7,750.6	69.3	13,185.8	67.1	5,193
Continuous					
Stop	1,532.7	13.7	3,106.3	15.8	
2-speed	1,367.2	12.2	2,587.7	13.2	
3-speed	534.6	4.8	773.3	3.9	
Total continuous	3,434.5	30.7	6,461.3	32.9	3,132
Total installations	11,185.1	100.0	19,647.1	100.0	*8,325
Automatic Train Stop	9,283.3	83.0	16,286.1	82.9	
Speed Control	1,901.8	17.0	3,361.0	17.1	

*Includes 250 multiple unit cars. Includes 198 locomotives equipped for operation over the installations of other carriers.

Note 1. Voluntary installations included in above figures as follows: 2,841.2 miles of road, 4,557.4 miles of track, 768 locomotives. All other installations made in accordance with requirements of Interstate Commerce Commission.

Note 2. Cab signals in use on all "continuous" installations.

Note 3. About 1,700 miles of track operated without wayside signals except at certain essential locations.

Intermittent vs. Continuous Control

Attention has been called to the classification of automatic train control as either intermittent or continuous. In the intermittent, the train control is in effect only at specific points on the track, ordinarily at signal or braking point locations. This system operates as follows: wayside inductors, either inert or magnetic, are connected with the automatic block signal circuits. These inductors actuate receivers, carried usually on the engine tender, in such a manner that the brakes are given an automatic service application whenever a wayside inductor is passed at a signal showing a restrictive indication unless the engineman acknowledges as he passes the inductor. No automatic brake applications nor warnings are received at points other than those at which inductors are located.

In the continuous system, the locomotive apparatus is controlled continuously by electrical circuits on the

(*Continued on page 28*)

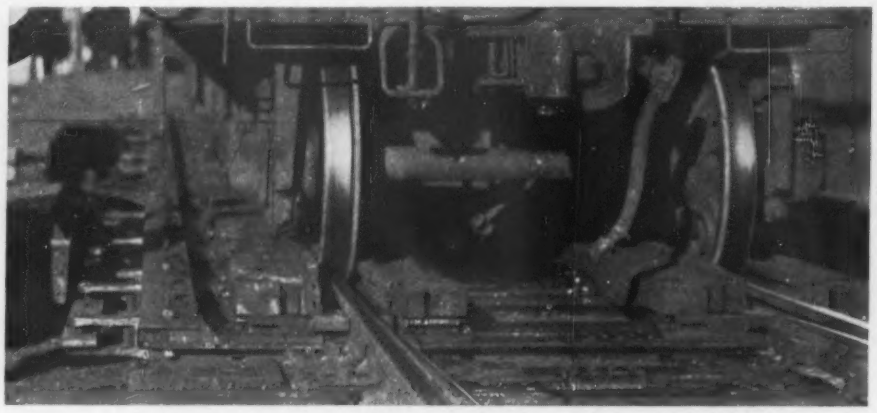
Modern Freight Transportation

The application of the mechanical car retarder brings about increased efficiency in railroad yards

By LAWRENCE RICHARDSON
Mechanical Superintendent
Boston and Maine Railroad

DEVELOPMENTS in modern freight transportation are occurring with rapid frequency and, in many cases, with drastic changes. Pressure from the shippers has brought about a demand for faster and surer freight transportation, the speed in many cases equaling express service. The increased use of motor trucks has decreased the amount of local freight handled, the proportion to the total freight dropping materially.

At the beginning of the century, the average haul per ton of freight was two hundred forty-six miles; by 1926 it had increased to three hundred ten miles. There was an attendant increase in the carload owing to the reduction of the light, less-than-carload loads. The average in 1926 was 27.35 tons, an increase from 23.38 tons in 1915. The net result has been that American railroads are becoming more and more long-distance transportation agents — that is, wholesale transportation agents, rather than retail and whole-sale transportation agents, as in the past.



FREIGHT CAR LEAVING MECHANICAL RETARDER
An excellent view is obtained of the way in which the retarder applies pressure to the wheels, reducing the speed of the car.

The increase in business has been marked. In 1919, there were some 367,000,000,000 ton miles — in 1924, 391,000,000,000, and in 1926, 447,000,000,000. This increase was handled with no increase in track mileage. As a matter of fact, there are 396 less miles of railroad in the United States today than there were ten years ago. There has also been a reduction in the number of cars, there being in 1919, 2,426,889 cars to 2,403,961 cars in 1926. A reduction in the number of locomotives has accompanied this decrease, there being 2,839 less today than there were in 1924.

Summed up, the railroads are now doing 22 per cent more business with 9 per cent fewer cars. Consider the following data, taken from one of the eastern railroads. This road has reduced its number of locomotives from 1,120 in 1923 to 850 in 1927. It has also dropped from its lines some 12,000 cars. This has been possible because of the fact that it is doing less and less local business, and is increasing more and more in through business, the lines being free for fast through movements.

In addition to the change in traffic, there have been marked developments in yard design and construction, and also toward better and faster power. A representative locomotive in 1906 produced 8,810 gross ton miles per train hour — a representative locomotive in 1916 brought this figure up to 12,490 tons, while today it is some 20,000 gross ton miles per train hour. In other words, the locomotive of today is producing two and one-half times as much as it did twenty years ago.

The modern locomotive of 1921 used 5.66 pounds of coal per drawbar horsepower. The succeeding development in 1922 brought this figure to 4.44, while in 1925 the latest development in economical power has brought the figure below three, the actual figure being 2.98 pounds per drawbar horsepower.

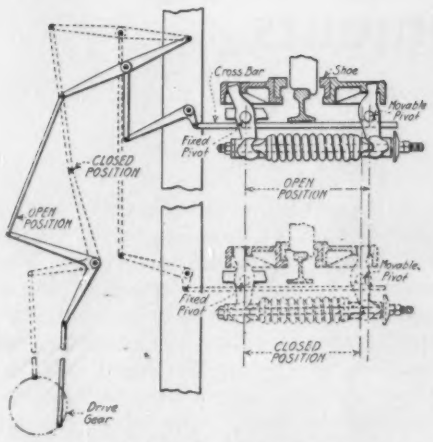
To handle modern trains, the roadbed has necessarily been improved. Rock ballast and heavier rails have been employed. The latest rail on the heavy traffic divisions has a weight of 130 pounds to the yard, this weight being used primarily to give a smoother roadbed and at the same time materially to reduce maintenance cost.

To better visualize the increase in speed, a brief survey of a concrete case is enlightening. A committee appointed to investigate freight conditions found that the average time of the freight movement between Rotterdam Junction, N. Y. and Boston, Mass. was 143 hours. The committee thought there might be a possible reduction of 92 hours. Not only has the time been reduced to 51 hours, it has been reduced further until today trains are coming through in 18 hours. This speed has been largely possible through the use of car retarders in the yards at Mechanicsville, N. Y. Cars on preference trains spend only an hour and a half at that point, and only an hour to an hour and a half in Boston. Trains arriving are inspected in fifteen minutes, and humped in another fifteen minutes, classification not taking over a half hour when necessary.

Although there has been a drop in operating revenue of $4,000,000, the drop in operating expenses has been $9,000,000. The drop in revenue therefor has not only been met, but largely offset; the net showing an appreciable increase, rather than a drop.

The greatest reduction of time has been in the yard operation, the speeding up being accomplished largely through the use of car retarders. These are a development of recent years, having been invented by President Hannauer of the Boston and Maine Railroad, while he was connected with the Indiana Harbor Belt.

For twenty-five years, the so-called hump yard had been generally conceded to be the most economical means of classifying cars. These yards had one or two tracks graded to a summit, over which cars were pushed by humping engines usually at a speed of from two to four miles an hour. The cars were uncoupled by the conductor of the humping crew just before they reached the summit and were run by gravity down the far side of the hump to the proper classification track. Car riders or brakemen controlled the speed of the cars down the hump to prevent them from running into other cars at a speed that would damage cars and lading. After delivering cars to proper tracks, the riders either walked back to the hump, or were carried there by motor cars, a considerable part of their time being spent in returning. Then too, unless traffic was fairly uniform,



SECTIONAL DRAWING OF RETARDER
This illustrates the clamping action from the open to the closed position

they spent a great deal of their time waiting for trains to be humped. Where traffic was not uniform, it was difficult to provide enough riders to take care of traffic when it did come, and at the same time not have too many for fairly economical operation. The result was that there was a great deal of delay, especially when the trains became delayed or bunched.

With retarder operation it is possible to work a yard to its maximum capacity for a very short period of time, and at the same time not have uneconomical operation. This is made possible because the number of men employed is a minimum, and at the same time the yard and engine crews employed can be used to full advantage throughout the entire shift; that is, when they are not humping they are used in trimming and other necessary yard work. The number of men that are affected by periodical work is often as low as two, they being the tower operators. Even then a great deal of their spare time is utilized to advantage in recording and other work. The cost of providing enough riders to handle peak business properly in some yards frequently shows lost time running into several hundred dollars a day, while in car retarder yards the value of lost time is often reduced practically to nothing.

The first retarders were constructed from convenient railway materials, such as car springs and brake cylinders. Refinements in design have progressed to the point where practically every member has been designed for the required service and manufactured accordingly.

The car retarder is a track brake which presses against both sides of the lower part of the car wheels in the same manner as a vise, the pressure being controlled by an operator according to the weight and speed of the car, heavy retardation for a heavy load, little or no retardation for an empty. There are two types of car-retarder systems in service on the railways of the United States: the all-electric system, in which retarders, switch machines, and skate machines are controlled and operated by electric energy; and the electropneumatic system, in which similar units are controlled by electric energy, and operated by compressed air.

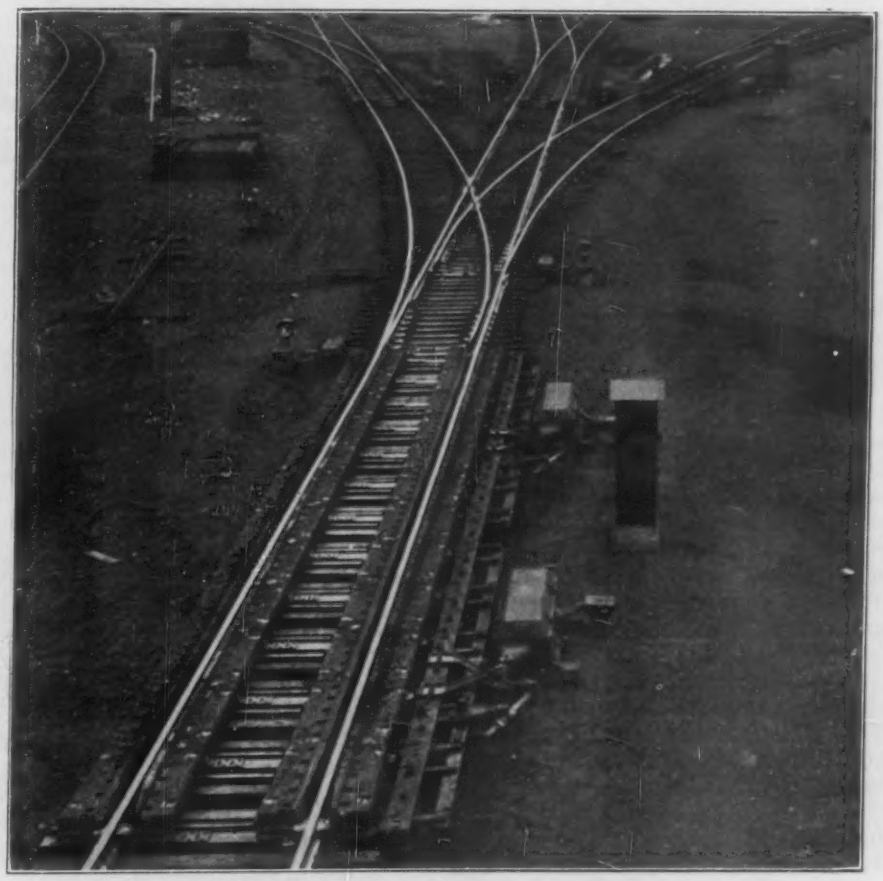
The shoe beams are of special alloy steel, articulated to prevent binding due to variation in the grade of the track. The top of the brake shoe is 2 inches above the top of the rail. The wheel space is 7 inches open and 4 inches closed. Car retarders are ordinarily 33 to 40 feet long. The latter is the maximum length operated by one mechanism; if greater lengths are required, two or more units are used. The construction of a retarder is such that there is little chance of any dragging car equipment's fouling the retarder, and a derailed car could do little damage, owing to the heavy and substantial parts, capable of bearing the weight of a car or a locomotive. The cranks are mounted in heavy longitudinal members bolted to the ties. The long arm of the crank is attached to a longitudinal operating bar, which is connected to the mechanism. The short arm of the crank is connected to cross-members which operate the spring mechanism under each rail.

All forces are self-contained in the mechanism. Under extreme conditions the maximum stress in the members is not over 30,000 pounds per square inch, and under normal conditions about 15,000 pounds.

In the all-electric retarder the mechanism case is bolted to a longitudinal angle and two ties near the middle of the retarder. It houses a motor with suitable reduction gears; a powerful brake that holds the motor stationary, which is released only when power is applied to the motor; and a master circuit controller. For simplicity and for economy in wire, the operating circuits are local, and the master controller in the mechanism controls heavy-duty forward and reverse contactors in a separate housing at the main power line.

The mechanism is attached to the longitudinal operating bar by means of a toggle arrangement, which produces a fast movement when the retarder begins to close and a slower movement with enormous pressure when the retarder is near the closed position. Should by any chance a car be lifted, the inner shoes serve as guard rails, and the car would drop back on the rails after clearing the retarder.

(*Continued on page 36*)



RETARDER IN OPEN POSITION
The boxes on the right contain the motors operating this device for slowing down cars before they enter the switch

Motive Power Developments

A pictorial section illustrating the latest practice in steam, oil electric and gas electric locomotives

WITHIN the past decade, the economic status of the railroad has changed. With the advent of the motor truck, the amount of local freight handled has decreased considerably. The railroad has become chiefly a long distance transportation agent. Accompanying this change of status, there has been a demand on the part of shippers for faster, surer transportation. To meet these changes, and to combat increasing operating costs, a great deal of attention has been focused on the efficiency of operation; in this there has been a gratifying increase as a result. Of the ways in which this increase has been accomplished one has already been described in this issue under the head of "Modern Freight Transportation." Another lies in the changes in design of locomotives.

For about eighty years there was no fundamental development in locomotives to make a pound of metal or a pound of fuel do more work. The demands of increased train loadings for greater power were met simply by increasing the size and weight of the locomotive, but nothing was done to increase the general efficiency of the machine. After that period, the same tendency prevailed, except that locomotive sizes and weights grew more rapidly than ever until, at the present time, existing roadways and structures have about reached the limit of their capacity. The demand for more power is increasing nevertheless.

The past five years have seen great improvements in the steam locomotive which have made possible the development of more power without exceeding the existing wheel loads and clearance and have provided for the generation of more power for the same amount of fuel. The locomotive pictured here has been selected as typical of the general class of locomotives that have been the result of this evolution. It might be interesting to note the following figures: In 1921 a representative Mikado engine produced a cylinder output of 2,300 horsepower; in 1925 an improved locomotive of a design similar to the one pictured here having the same driving wheel load produced a cylinder output of 3,675 horsepower. The Mikado took 5.66 pounds of coal per drawbar horsepower, while the later engine took but 2.98 pounds of coal per drawbar horsepower. The photographs* show some of the more interesting features of this locomotive.

*Courtesy Lima Locomotive Works, Inc. and The General Electric Co.

Figs. 1 and 4 are side views of the locomotive.

Fig. 3 shows the front end of the locomotive. The shroud-like affair almost semi-circular in shape is the Coffin feedwater heater. The centrifugal pump which operates this feedwater heater can be seen directly behind the last side rod in Fig. 7.

Fig. 7 shows a perspective view of the rod drive of this locomotive. Notice how the back rod becomes a part of the main rod since it is located in the fork of the back end of the main rod, and since it bears on a steel bushing pressed through the entire assembly. It can readily be seen that the piston thrust is transmitted directly to the back driver without passing through the main side-pin on No. 3 driver wheel.

Figs. 5 and 6 show the four-wheel articulated trailing truck, in Fig. 5 equipped with booster and ash pan ready for installation under the locomotive. Fig. 6 shows the usually unseen part of the locomotive booster on the rear trailer axle.

Locomotives of twenty years ago had the fire box located between the frames, the grate area being necessarily limited. As locomotives grew in size, the boiler capacity increased, fire box and grate area accordingly enlarged. This enlargement was made possible by the introduction of the two-wheel trailer truck to carry the additional weight. The demands on a locomotive have increased to a point where a four-wheel truck is necessary.

The booster has been utilized to add power at low speeds. It has gears which are thrown into mesh when the engine starts, and these operate an extra pair of drive wheels until the engine has attained a speed of eight to ten miles per hour. Instead of designing the entire engine for the starting effort, it is possible, by means of the booster, to design the engine to give full efficiency at higher speeds. As speed is necessary in modern freight transportation, this constitutes a direct saving.

Fig. 8 shows the hinge casting which is securely fastened between the main frames of the locomotive, and on which the front portion of the articulated truck pivots. The cut-out portions of the main frame are to take the side bearings on the front part of the articulated truck, shown in Fig. 6.

Fig. 2 shows the cab of the locomotive. The wheel at the right of the picture, near the cab window, is the booster control. Directly under the window is a box-like affair; this is the train control acknowledger. The throttle lever hangs vertically downward, with the handle in line with the right front window. The group of small levers below the handle of the throttle lever control the sanders, cylinder cocks, bell ringer, etc. The assembly to the left of the wheel is the automatic brake valve. Directly behind the wheel is the reverse lever. Underneath the fire door is a group of valves; these are the stoker jet controls. Both sides of this group are the housings of the grate shaking levers. Above the fire door is a group of gauges; the top gauge is the superheated steam pyrometer. On the right of this group is the water column and gauge; to the left is a water gauge. The long horizontal rod immediately beneath the group attached at the left to a valve is the water pump throttle. The two valves nearest the left side of the cab are the stoker engine throttles. Underneath the left window is the valve controlling the blower.

In a different field of modern transportation are the oil and gas-electric locomotives. They are comparatively recent additions to the means of transportation. They are particularly useful in gaining the advantages of electric engines without needing the great expense required for electrification of a railroad. Local transportation finds practical use for them, too. The oil-electric locomotive is the most used of the two.

Fig. 10 is a perspective view of an oil-electric locomotive built for the New York Central Railroad. It is equipped with McIntosh & Seymour 900-horsepower diesel engine, with G-E generator, motors and control.

Fig. 9 shows the arrangement of the motors on the trucks.

Fig. 11 is a cut away view of a typical oil-electric locomotive, showing the arrangement of the principal parts.

Fig. 13 is a view of two gas-electric locomotives built for the Chiriqui Land Company. The one to the left is a 20-ton, the one to the right a 25-ton locomotive.

Figs. 14 and 15 are interiors of a locomotive, showing the arrangement of the engine and generator.

Fig. 12 is the end view of the 20-ton locomotive showing the arrangement of the rheostats and generating set.

J. H. DODGE, JR., '31.

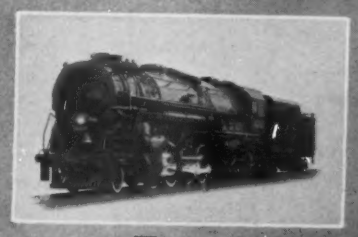


FIG. 1

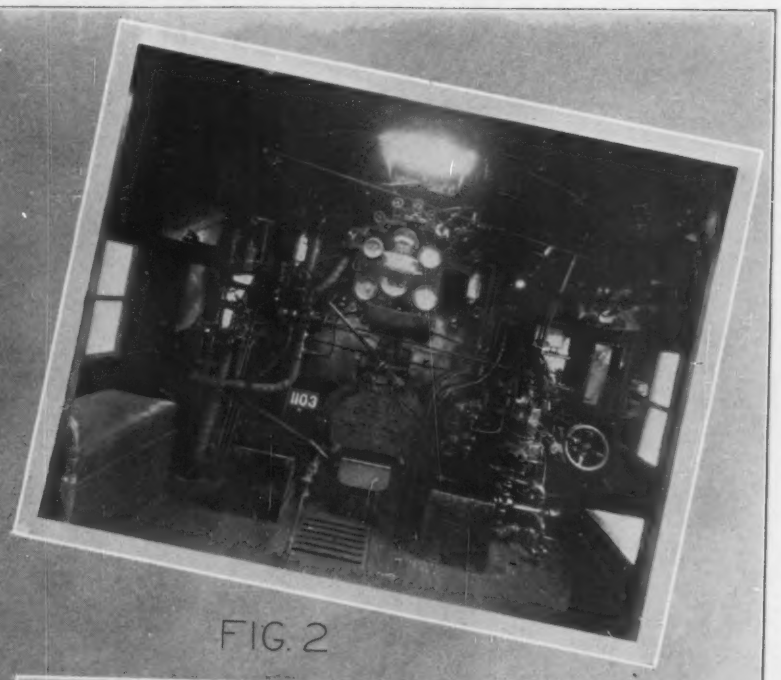


FIG. 2

FIG. 3

FIG. 4

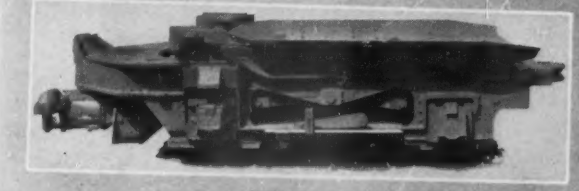


FIG. 5

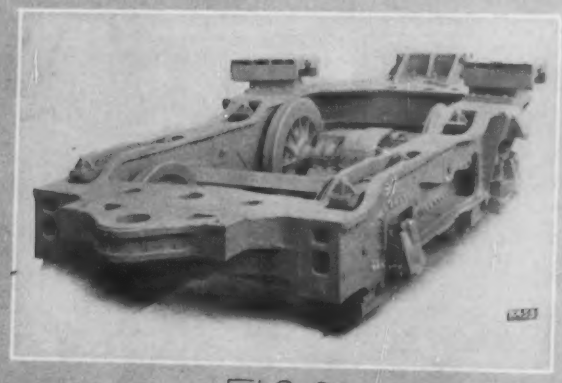


FIG. 6

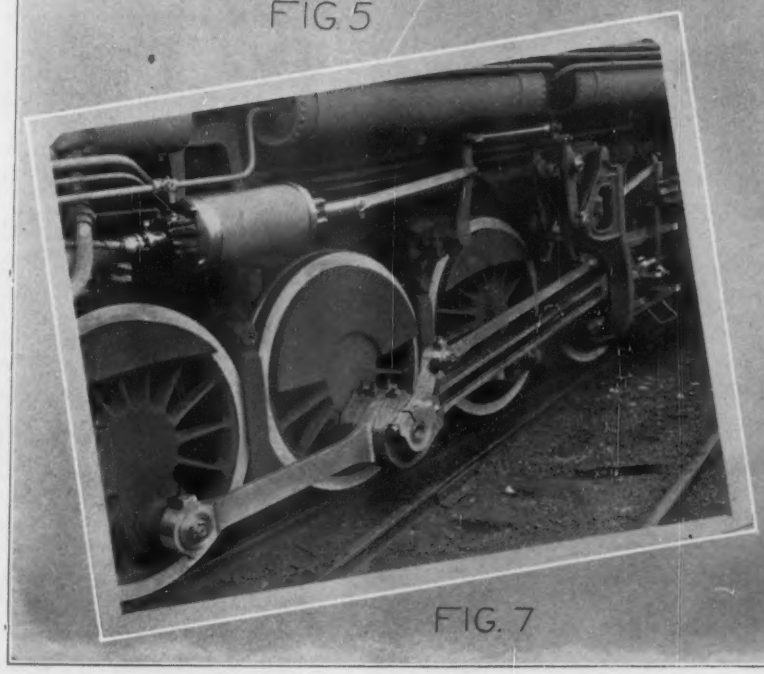


FIG. 7

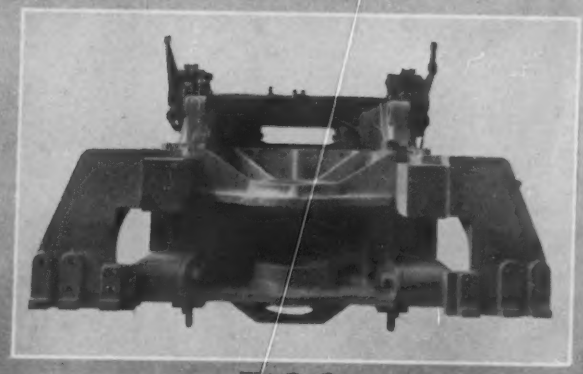


FIG. 8

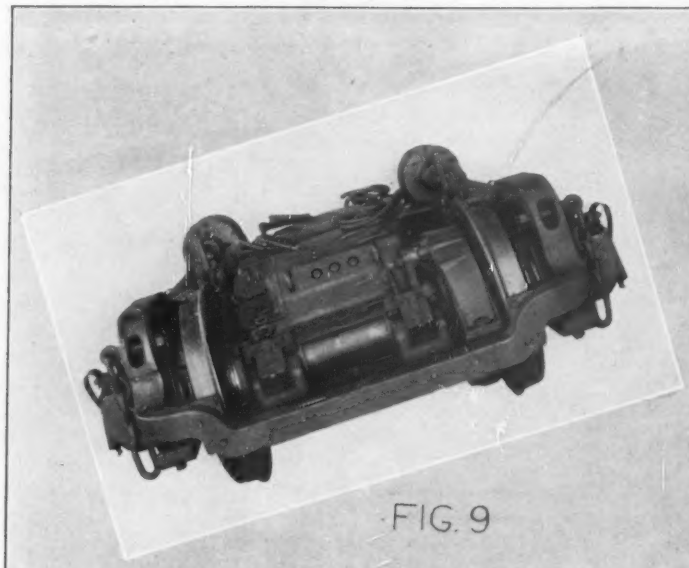


FIG. 9

FIG. 10

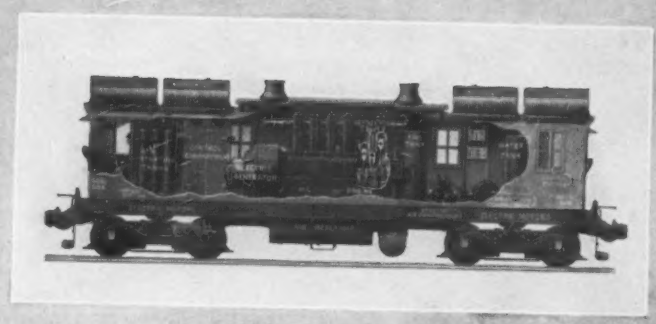


FIG. 11

FIG. 12

FIG. 13

FIG. 14

FIG. 15

Editorials

PRESENTING VOLUME TEN

With the first issue of Volume X, another page in the history of THE TECH ENGINEERING NEWS has been opened, not to be closed until a year from this time when a succeeding Managing Board will receive the responsibilities of controlling the policies of the magazine. It is with no feeling of confidence that we newcomers take over the reins that have been handed to us, for we realize that our predecessors have set an exceedingly difficult standard, one which we must constantly strive to maintain and, if possible, to surpass, raising the quality of our work to a higher level.

In any new undertaking, it is well to pause at the start and make sure of one's aims that the goal may be really worthwhile, and that the path to the goal may be well chosen and direct. Above all else, it will be our effort during the coming year to publish a magazine which shall be interesting, to present articles which shall have a genuine appeal to our readers, both in the choice and value of the subject and in the manner in which the subject is presented. We hope to devote more space to the human problems of engineering, to discussions of the duties and responsibilities of the engineering professions, and to the opportunities they offer to the young man of today. To determine what are those things along engineering and scientific lines which most interest our undergraduate and alumni readers, and then to satisfy that interest, is our aim.

With our next issue, we plan to introduce a new feature in the publication of a monthly sketch of some prominent member of the faculty here at the Institute. While many of us are in daily contact with our instructors, we are for the most part ignorant of those facts concerning their professional training and experience which have qualified them for the positions they now occupy, and which give them their place of prominence in their respective fields. It will be the purpose of these sketches to tell something about the man's early training, his industrial experience, his career in educational circles, in short, to acquaint the student with many important facts concerning the background of his instructor of which he is probably unaware. Such knowledge cannot fail to bring about a greater appreciation of the teacher on the part of the student and a corresponding increase in the educational value to be derived from the course.

At all times criticism of the editorial policies as to articles, features, or regular departmental work will be welcome. In the coming year we shall probably make mistakes, we may fall short of our goal, and if we do we hope that our readers will feel free to call it to our attention. If we are to bring the nature of the magazine closer into harmony with their desire, we will first need to know clearly just what the desires of subscribers may be. Through criticism from the outside we are enabled to see ourselves as others see us, finding the way toward real progress, with the hope of leaving THE TECH ENGINEERING NEWS a year from now a better and stronger magazine than at the present time.

THE COVER

In keeping with the spirit of the railroad issue, our cover this month shows a locomotive of the latest design hauling a long freight through the Berkshires. The picture is reproduced through the courtesy of the Lima Locomotive Works, Incorporated, manufacturers of the engine.

THE RAILWAY ISSUE

The railroads of the United States have always played an important part in the development of the industrial civilization with which we are familiar today. In the railroad industry itself engineers have been called upon to play many of the leading roles, for the construction, operation and maintenance of a highly developed transportation system requires the knowledge and qualities characteristic of our profession. Many M. I. T. alumni have reflected credit upon their Alma Mater by their success in this field, and in the newly established coöperative course in railroad operation students are receiving instruction along this line.

In view of the great importance of the railroads and the widespread interest shown in their problems, this special railway issue was planned. In it are several articles discussing the latest developments and improvements in the industry, as well as a pictorial section devoted to the subject of various kinds of motive power. Within the covers of a magazine it is obviously impossible to present a detailed and complete picture of so large an industry and we have chosen to select a few significant developments for our attention, treating them rather carefully rather than trying to inadequately cover a wider field. In following months, and in a similar manner, we plan to present special issues concerning other fields of engineering activity.

IDEAS OF AN INVENTOR

In accordance with our usual policy of including an article of general interest among the more technical articles of a special number, we are presenting in the present railroad issue "Ideas of an Inventor" by Georges Claude, renowned scientist and inventor. We feel that this article will be of absorbing interest to all our readers, for the principles brought forth are related not only to the many branches of engineering or science, but are applicable to all fields of human endeavor.

One of the inevitable results of reading the paper is a realization of the value of imagination. This quality, so essential to a successful man no matter what his pursuit, is of especial importance to the inventor, and the part it may play in a career is strikingly demonstrated in the life of M. Claude. One of the reasons for the failure of so many well-educated persons is the lack of imagination. It is an attribute that cannot be cultivated too highly, especially by the student who has hopes of becoming a leader in his chosen profession.

Character is strongly emphasized by the author, and the essence of his ideas on the subject is well expressed in these, his own words, "The greatest difficulty for an inventor comes chiefly not from matter but from man, and in consequence the quality which in my opinion stands by far at the highest place among all those necessary in that hard profession of invention is character." In place of the word "invention" we may easily substitute the name of our field of endeavor, for the principle is a general one. While reading the article it would be well to keep in mind our own seemingly unsurmountable difficulties and apply those effective methods of solution demonstrated in the article.

AN OMISSION

Through an oversight, the index of articles and authors of Volume IX which customarily appears in the last issue of a volume of THE TECH ENGINEERING NEWS, was omitted from the January issue. Accordingly, the index has been included in the rear of this number, and we trust that our readers have not been inconvenienced by its delay.

The Engineering Field

Abstracts from the leading professional and trade journals

Ballast-Cleaning has been successfully accomplished by the Pennsylvania Railroad by means of machines which dig up the ballast from between the tracks and pass it through screens to separate the dirt from the stones.

Two steel-frame cars are required to carry the machinery, one for the ballast-digging and the other for the cleaning. On the former is mounted a 300-kw. generator driven by a 300-h.p. gasoline engine to furnish the current for the cable drum, operation of buckets, air compressor and other mechanisms. The two one-half yard grab buckets, which move laterally on curved guides so as not to foul trains on the adjacent track, have a spread of eight feet and dig up ballast for half the width between the ties.

When work is begun, the locomotive is uncoupled and set 500 feet ahead with the brakes on. A cable attached to the locomotive is wound up on the cable drum on the digging car. First, with the machine at rest, the buckets pick up the ballast, ride up the curved guides and dump it into a hopper. Then, while the machine moves seven feet, the ballast is carried by conveyor to the cleaning car where it is placed before screens and compressed air blown through. The clean stones are then dropped by a chute to the space between the tracks, while the dirt is carried by conveyors either to the side or to coal cars trailing after.

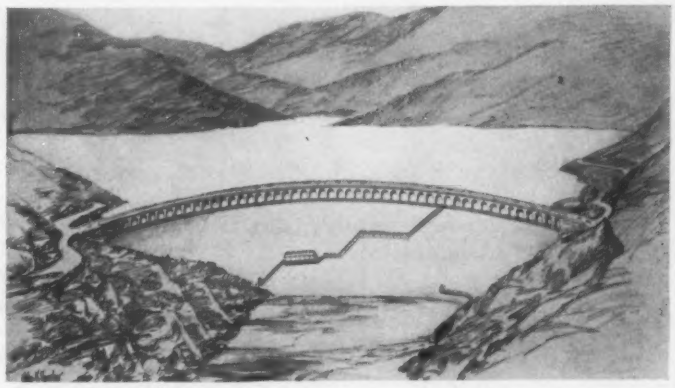
With this method of cleaning ballast 7500 feet of track can be covered in a day, resulting in the handling of about 2000 cubic yards of ballast daily.

A Duplex Leaf Valve, which differs radically in design from conventional types, is now being used by the Southern California Edison Company in an outlet from Huntington Lake to supply the Huntington-Shaver conduit. The valve which is motor operated has a capacity of 1400 sec. feet and is designed to operate under a head of 60 feet. By the use of two rectangular gate leaves in the same plane operated by horizontal stems, not only is the weight of the mechanism reduced and a smooth easily-regulated flow obtained, but the stress is distributed among four valve stems.

The two leaves of the valve are moved simultaneously by a 10 h.p. motor geared to a countershaft extending across the top of the valve. When the leaves reach the open position, and when they are within one-half inch of the closed position, a limit switch breaks the motor circuit. The actual seating of the valve is done by hand.

A further refinement in the design is the admitting of air into the valve, thus preventing any pulsation that might be caused by a vacuum forming on the downstream side.

San Gabriel Dam, the world's largest concrete dam, is now being built by the Los Angeles Flood Control District. This colossal structure, which will be 160 feet higher than any present dam and will contain nearly four times as much concrete as any dam in the United States, is absolutely necessary to cope with the rampaging flood conditions of the San Gabriel River.



Courtesy *Explosive Engineer*

SAN GABRIEL DAM

This barrier will be of the gravity section type, weighing 10,000,000 tons and arched with a radius of 1400 feet. It will be 492 feet high, 412 feet thick and 660 feet long where it rests on the foundation, while the top will be 20 feet wide and 2400 feet long. Fifty feet below stream bed level it will be anchored securely in solid granite by the blasting of series of corrugations in the rock, for which it is estimated that a million pounds of explosives will be needed. Much care is being exercised in building the foundation for defects in all dams are usually traced to foundational weaknesses. In addition, forty miles of tiled drain holes check and carry away seepage water before this water gets ten feet within the concrete face.

Taking care of 350 second feet per square mile of drainage area, San Gabriel Dam is designed purely for flood control purposes although through special state legislation it may also be used for irrigation or power purposes.

The Longest Steel-Arch Bridge in the world is now being constructed over the Kill van Kull connecting New Jersey with Staten Island, New York City. The arch span of this bridge will be 1675 feet in length, which will be 25 feet longer than the Sydney arch bridge being constructed in Australia and 680 feet longer than the famous Hell Gate arch in New York. In comparison with the Hell Gate arch it will carry a much lighter load and will have a lighter tonnage of steelwork. It is designed to provide for six highway lanes or four highway lanes and two rapid transit lanes, and it will become the closing link in a highway between Manhattan and Staten Island.

Arch construction was used instead of suspension because of the rigidity needed, the better appearance, the economy of cost, and the more gradual approaches possible. The two arch trusses which are more than 50 per cent nickel and silicon steel form true parabolas and provide a clear roadway width of 65 feet. At the center of the span a clearance of 150 feet is provided above mean high water. In setting the steel arch shoes accurately an ingenious method is to be used. They are to be riveted onto a steel frame which is cast into the concrete skewbacks on either side.

The engineering on this Kill van Kull arch bridge, which is to cost $16,000,000 when finished, is remarkable for its great length, grace of outline, simple foundations, use of heavy steel forgings for hinge bearings, unusually long floorbeams, and its use of alloy steels.

A New Type Bucket Excavator, which has four booms and bucket lines mounted in two units of two each, has been announced by a western company.

This machine is very accurate in digging, and since the material is dug by a constant milling action, it is broken up into small bits.

The operator has only to work the clutch at the beginning and end of each load and to watch the dials indicating the depth of cut and the relation of the boom units to each other.

Courtesy *Engineering News-Record*

THE NEW FOUR BUCKET EXCAVATOR

Helium is to be made in what may be called the "coldest spot in the world," which is eight miles west of Amarillo, Texas. This government plant will take helium from natural gas of the Amarillo field by cooling the gas down to 300° F. below zero, for then all the components of natural gas, except helium, will liquify and so helium can be drawn off as a gas. At this low temperature air becomes liquid, carbon dioxide and mercury become solid, while rubber would be as brittle as glass.

The economy of this production is such that the cost can be brought down to a few cents a cubic foot in comparison with $2000 a cubic foot before the World War. This helium is to be used to supply the Navy's giant dirigibles because it is felt that only helium is safe to be used in inflated airships.

A New Lifeboat Detaching Gear has been developed which has a one-man release as well as a one-man retrieve. The gear consists of a latch for connecting the lifeboat tackle blocks and a locking link that is engaged with it. This link is moved out of its seat by a lever when it is to be released. The operating gear is in the form of a strong shaft which extends the length of the boat under the thwarts. The entire apparatus is securely fastened to two cheek plates.

The operation of the gear is accomplished by moving a handle, which is located in a convenient position for the officer in charge of the boat, from a downward position to the horizontal. It is possible to release the gear either before or after the boat is in the water. In addition, a lifeboat equipped with this device may be launched from a ship travelling at full speed.

An important safety feature of the device is that the boat cannot be released at one end without releasing the other. Thus a mishap resulting from that cause is eliminated.

A Monster Electric Lamp using 50,000 watts has been designed in an Ohio laboratory. At the top of this gigantic lamp, which is three feet high, is a radiator composed of metal fins which carry off the intense heat generated by the white-hot Tungsten filament, which is at a temperature of 5500° F. Nitrogen gas is used to fill the bulb, and as the gas circulates it cools the bulb and carries upward into the radiator evaporated Tungsten particles from the filament, and so the walls will not be blackened. After the lamp had burned for fifteen hours on a test, the lamp showed no appearance of use.

The most important use of this immense lamp will be in airport lighting, for fewer lamps will need to be used and the light will penetrate fog and illuminate more efficiently than ordinary lamps.

A Grip Nut, which will not loosen or vibrate off when it is screwed onto a threaded bolt, has just been placed on the market.

In the manufacture, a blank nut has two slots cut in one side making this side 0.004 inch wider. The nut is then threaded, the threads on the slotted side consequently becoming shallower. Finally, this face is pressed together 0.009 inch making the slotted side 0.005 inch narrower than the other side. When threaded on a bolt the slotted side offers a springy resistance to the bolt and produces such a firm grip that lock washers, double locking nuts, and other holding devices are unnecessary.

Caterpillar Landing Gears on land planes has proved successful and its adaption to seaplanes has been predicted.

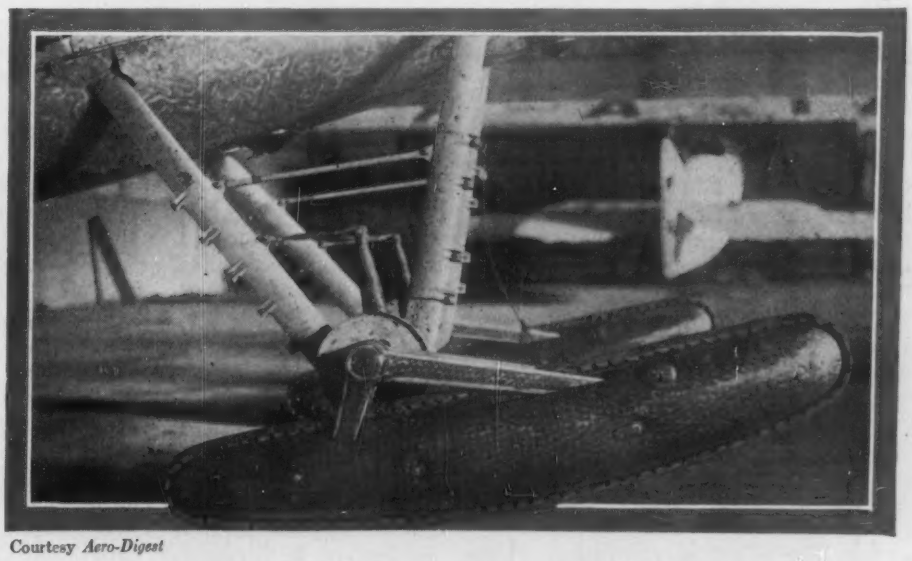
The test caterpillar model, five feet long and attached by ball and socket joints to the standard wheel mounting, was able to clear obstacles up to sixteen inches high. Due to its shape and the fact that in flight it is carried parallel to the chord of the wings head resistance is considerably less than that of the wheels replaced; and in spite of its cumbersome appearance it is no heavier than these same wheels.

Duralumin is used in the construction throughout except for rubber treads on the caterpillar and rubber cushions between it and the shell. Inside each shell is mounted a Westinghouse air brake which is controlled by a lever in the cockpit and operated by a tube leading from the intermediary of the carburetor except in emergencies when a special vacuum chamber may be used to apply the brakes.

In actual test before an official commission the invention proved highly successful, and its early adaption to seaplanes is awaited.

Sound-Proof Studios are now regarded as essential in the successful production of talking movies. Buildings which would ordinarily be considered sound-proof are found to be utterly useless in this work, for the introduction of even slight outside noises is enough to ruin an otherwise good picture.

The new structures are windowless and are constructed with outer shells of some sound reflecting material, while the inner walls are covered with a sound absorption material and are separated from the outer shells by an air space. The supporting columns are carefully insulated from the foundations, which are made as vibrationless as possible, and the roofs rest on heavy felt saddles, no nails or bolts being used to fasten them. Even the underground pipes which, in themselves, seem a minor source of vibration, are sunk in sand and covered with concrete.



Courtesy *Aero-Digest*

CATERPILLAR LANDING GEAR FOR AIRPLANES

Departmental Notes

DEPARTMENT OF CIVIL AND SANITARY ENGINEERING

AN appropriation has just been authorized by the Executive Committee of the Corporation for the purchase of a Wenner electrical recording seismograph which is to be installed at Camp Technology at East Machias, Maine. The location of the Camp is excellent for the establishment of a new seismograph station because of its remoteness from sources of local disturbances and its distance from other seismograph stations, the nearest important stations being those at Harvard University and at the Canadian Government Observatory at Ottawa. It is expected that this seismograph will be in continuous operation after its installation, under the supervision of Ernest O. Dennison, who is permanently located at the Camp, except at periods when the Camp is in full operation.

Annual observations have been made at the Camp for some years for the purpose of determining whether there is any permanent movement of the earth's crust. In pursuance of this work, a base line with an accuracy of one in one-million has been established; eight permanent triangulation stations, two of which were established by the United States Government, are available; and a line of precise levels covering already a length of thirteen miles is being extended. The Department is equipped with a Hildebrand theodolite capable of measuring angles to a precision of one second, and leveling instruments of the highest degree of precision obtainable. The addition of the seismograph should make this Camp one of the important stations of the world for the study of movements of the earth's crust.

The scientific work at Camp Technology along the lines described above, is under the direction of George L. Hosmer, Professor of Geodesy in the Civil Engineering Department.

The New England Power Construction Company has recently entered into an agreement with the Institute to conduct experimental investigations of earth pressure upon retaining walls. The specific purposes of the investigation are to obtain information concerning the following subjects:

(*a*) The intensity of the lateral earth pressure exerted by the backfill against rigid retaining walls.

(*b*) The effect of a concentrated surcharge on the intensity of the lateral earth pressure.

(*c*) The effect of saturation of the backfill on the intensity of the lateral pressure acting on the wall.

(*d*) The effect of various drainage arrangements on the intensity of the lateral earth pressure exerted by the saturated soils.

Under the terms of this agreement, the Institute furnishes the land and pile foundations for the experimental plant and agrees to provide the lighting, heating, sewerage and other similar facilities for the building. It also agrees to furnish through the Civil Engineering

PROF. C. M. SPOFFORD
[Head of Department of Civil and Sanitary Engineering

Department the general layout of the retaining wall and to specify the requirements for the measuring devices, and through the Mechanical Engineering Department to provide working drawings and detailed specifications for the measuring devices and to supervise their construction, installation and calibration. The New England Power Construction Company provides all the necessary constructions above the foundations, including fireproof building, concrete bins, and loading and measuring devices. The investigation will be made under the direction of Dr. Charles Terzaghi of the Civil Engineering Department.

The site selected for the foregoing experimental plant is near Building 46, now used by the Military Department, and adjoins the tracks of the Boston & Albany Railroad, lying between the railroad and Vassar Street.

It is believed that the results of these experiments upon earth pressure will prove of great value to the engineering profession in furnishing experimental data not hitherto available.

A series of lectures upon hydraulics with special reference to experimental investigations of stream flow are to be given at the Institute during the coming term (March 18 to April 6) by Dr. Theodor Rehbock, Professor of Hydraulics at the Technische Hochschule at Karlsruhe, Germany, since 1899. Professor Rehbock has an international reputation as an authority upon stream flow and the regulation of rivers and harbors. The new laboratory at Karlsruhe constructed in 1925, replacing the first laboratory established by Professor Rehbock in 1901, is perhaps the most extensively equipped laboratory for conducting water flow experiments of any laboratory connected with an educational institution.

Coöperative work in Soil Mechanics with the Bureau of Public Roads of the United States Department of Agriculture is being continued for the third successive year. An interesting piece of work under this agreement, now being conducted upon the Institute's land west of Massachusetts Avenue, has to do with the determination of the reasons for the heaving of soil under frost action. This test is being directed by Arthur Casagrande, a representative of the Bureau of Public Roads, who has been stationed for the last two and one-half years at the Laboratory of Soil Mechanics to represent the Bureau in the carrying out of the experimental work entered upon jointly by the Bureau and the Institute. He is assisted in this work by George N. Mangurian, a candidate for the degree of Master of Science in Civil Engineering.

A coöperative agreement has recently been made between the Institute and the Sewer Department of the City of Worcester, Massachusetts, for the purpose of facilitating the instruction of Institute students who wish to enter the field of sewage treatment and disposal by providing them with the opportunity to acquire by actual experience familiarity with the methods of sewage treatment in an important treatment plant. As a result of this agreement, a week's laboratory course is provided for the first time in April of this year at the laboratory of the City Sewage Treatment Plant in Worcester, where fourth year and graduate students in Sanitary Engineering will be given the opportunity to participate in the actual work of this laboratory and the operation of the plant, in which they will receive instruction from Roy S. Lanphear, Supervising Chemist of the plant, as well as from Prof. R. G. Tyler, who is in charge of instruction

(*Continued on page 34*)

He united the country with nails

BEN FRANKLIN made the horseshoe nail a symbol of the importance of little things. "The kingdom was lost and all for the want of a horseshoe nail", goes one of his wise sayings. So when he became Postmaster General, he knew full well the need for proper horseshoeing as one step in punctual mail schedules.

The care given to details can still make or break a great plan. In the telephone industry, for example, the development of compact paper insulation helped to make possible the small diameter cable and therefore the vast underground plant necessary to serve large cities.

A multiplicity of details, from the testing of long fibre cotton to the "voice with the smile", offer a continual challenge to the Bell System men who unite the nation with telephones.

BELL SYSTEM

A nation-wide system of 19,000,000 *inter-connecting telephones*

"OUR PIONEERING WORK HAS JUST BEGUN"

Recent Books

This department conducted in co-operation with the faculty

Winter Construction Methods. By CHARLES S. HILL, *Associate Editor, Engineering News Record. McGraw-Hill Book Company, New York. 180 pages, illustrated. Price $3.00.*

The winter has always been the slack season for the building trades, hitting both the employer and the employee. The former has his overhead continued undiminished, while his equipment lies idle, bringing in no return, and depreciating rapidly unless it is adequately stored. The workman finds himself out of a job when money is most needed, for work is always scarce in the cold months.

However, every year sees more work being carried on in the winter. There are as yet no definite rules or formulae laid down for procedure, but a technique is being perfected. This book, "Winter Construction Methods," goes a long way to codify current practices which have been shown by experience to be rational. While it is evident that the writer is very much in favor of carrying on winter construction, he does not become overoptimistic or one-sided on the subject, but warns of the dangers, and states that every constructor doing winter work assumes an extra risk which must be guarded against.

The subject is first approached from an economic standpoint. Extra costs directly due to winter are balanced against savings resulting from cheaper material, a greater activity on the part of labor, etc., and the conclusion is drawn that winter construction costs between 5 to 10 per cent extra. This is more than balanced by the saving in time.

The writer then discusses the actual problems to be met in winter work. The care of the labor, the efficiency of labor, the protection of the water supply, and fire protection are some of the subjects considered. Much space is given to the care of equipment, such as tractors, mixers and other machinery in sub-freezing weather.

The biggest problem of all — the placing of concrete in cold weather and its protection, once in place — is given the rear half of the book. Every possible angle is covered and successful methods tried by various concerns for keeping material piles thawed for covering the job, for heating the inside once it is covered, for placing and transporting the mix, etc., are all taken up. Wherever possible, numerical values and formulae are given, and the discussion is applied to work on dams and bridges as well as buildings.

As a net result of his study of winter construction, Mr. Hill gives the following:

1. The knowledge that most kinds of construction can be carried on under the most severe conditions.

2. A summary of the principles and practices which have thus far proved successful.

3. A clear conception of what is not yet known, and of the great need for further research after the constants and formulae by which winter construction may be materially planned and carried out.

W. B.

Principles of Mechanism. *By* F. DYSON. *Lecturer in Mechanical Engineering at the City and Guilds (Eng.) College, Imperial College of Science and Technology, London. 296 and VIII pages, 148 diagrams. Oxford University Press, American Branch, New York. Price $4.25.*

This book by an English author and engineer, Mr. F. Dyson, is clearer and more readable than many texts of similar nature produced in this country. It is written in a direct, straightforward, conversational style, making it very easy to read and study. His style carries the author smoothly over such difficult subjects to explain in writing as epicyclic gear trains, velocity and acceleration diagrams, etc. It covers much the same field as an American book on Mechanism, but at the same time presents many interesting differences.

The English nomenclature is unusual. Kilowatt hours are "Board of Trade units," four bar linkages are "quadric cycle chains" and crank mechanisms are "crank chains." "Spiral gear" still persists in England, instead of the more accurate term helical gear.

An elementary knowledge of Applied Mechanics has been presupposed, though the author has cautiously slipped in a chapter of review — and a very good chapter it is. Several things are included under the heading of Mechanism which we would expect to find in an Applied Mechanics text. For instance, a detailed mathematical analysis of friction is included, seemingly with no connection with the rest of the work. An excellent chapter on the balancing of rotating bodies has also been included.

The book is well supplied with solved and unsolved problems and answers. It is highly recommended to students as a reference text.

J. H.

Standards and Standardization. *By* NORMAN F. HARRIMAN. *Published by McGraw-Hill Book Company, Inc., New York. 265 and XVI pages.*

This medium-sized book is apparently among the first if not the very first in the English tongue to deal with the subject of standardization. In view of the remarkable importance and growth of standardization in industry during and since the war, this seems a very unusual situation and should ensure an immediate and widespread field of usefulness for the work.

The subject of standards is treated essentially as an introduction to the major theme of standardization. The evolution of standards is traced through the development of industry in our present civilization. The units of measurement are outlined and the development of the standards for measurement fully explained. It is truly said that the greatest achievement of modern science is its ever-increasing capacity to measure, which has resulted in increasing refinement of standards of measurement until today the real standard of length is the wave length of light. Standard constants, standards of quality, performance, and practice are considered.

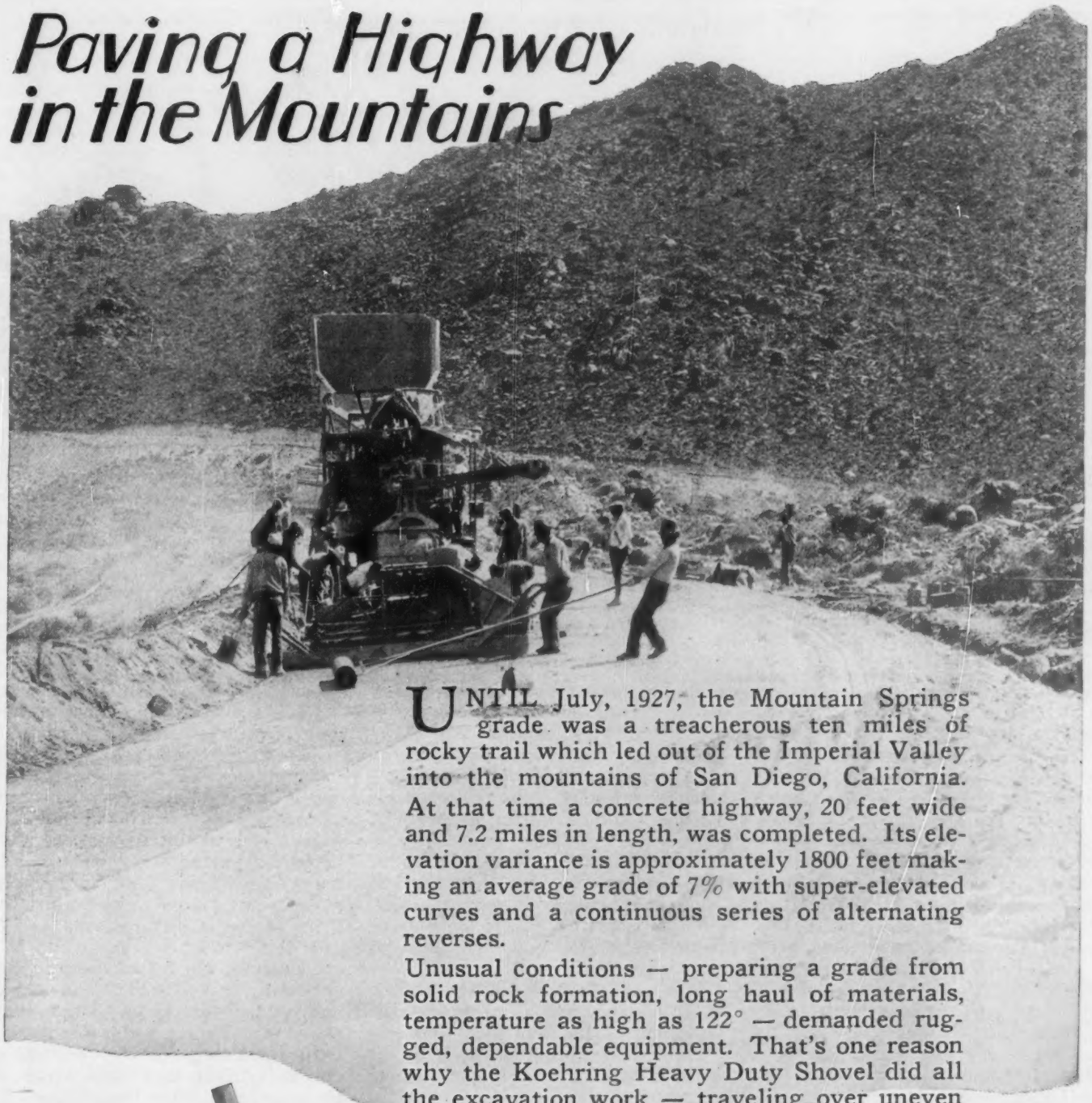
While one fails to concede that standardization is in any way the bedrock of civilization, yet it surely should be the bedrock of industry in this machine age. Inasmuch as standardization is foreign to the individuality and apparent interests of man it required a great national emergency, the war, to bring home its importance and force its application. Its progress since that time has been as remarkable as its previous absence.

In the treatment of standardization some of the more important elements of the subject have been selected and treated concisely and accurately rather than exhaustively. The advantages of standardization to both consumer and producer are carefully analyzed as are the reasons which hinder its progress. The main object of standardization is the elimination of waste in all departments of industry and activity; this process is commonly called rationalization abroad and this term is much more pleasant to the ear of the layman than standardization which seems inevitably linked with the idea of robots.

Necessarily the manufacturing industries are given the most space and yet the business man and the pure scientist should find fully as much of value as those engaged directly in

(*Continued on page 40*)

Paving a Highway in the Mountains



UNTIL July, 1927, the Mountain Springs grade was a treacherous ten miles of rocky trail which led out of the Imperial Valley into the mountains of San Diego, California. At that time a concrete highway, 20 feet wide and 7.2 miles in length, was completed. Its elevation variance is approximately 1800 feet making an average grade of 7% with super-elevated curves and a continuous series of alternating reverses.

Unusual conditions — preparing a grade from solid rock formation, long haul of materials, temperature as high as 122° — demanded rugged, dependable equipment. That's one reason why the Koehring Heavy Duty Shovel did all the excavation work — traveling over uneven rock formation.

At the stock pile and batcher bin a Koehring Heavy Duty Crane handled the crushed rock and sand while on the grade a Koehring Heavy Duty Paver mixed the dominant strength concrete, — a complete Koehring-equipped job.

"Concrete — Its Manufacture and Use," a complete treatise and handbook on present methods of preparing and handling portland cement concrete, will be gladly sent on request to engineering students, faculty members and others interested.

KOEHRING COMPANY
MILWAUKEE, WISCONSIN
Manufacturers of
Pavers, Mixers—Gasoline Shovels, Cranes and Draglines

KOEHRING HEAVY DUTY

KOEHRING

Ideas of An Inventor

(*Continued from page 8*)

air especially for this purpose, I devoted my efforts to obtaining them as by-products, and therefore at a low cost, during the normal operation of the large industrial oxygen apparatus.

The first two rare gases I obtained in this way were neon and helium. Contrary to the methods of Sir W. Ramsay, who got them in the first portions of evaporation of liquid air, I sought and found them in the unliquefied residue of the progressive and methodic liquefaction of air.

The extraordinary electric properties of neon make it a very interesting substance. It produces light, I dare say, as birds sing.

According to my idea that the specific properties which certain substances possess to an exceptional degree are our most powerful resources in solving problems, I engaged myself in 1907 in the question of neon lighting. As early as 1911 such were the results of my work that I did not hesitate to buy my patents from my Société l'Air Liquide to which they belonged, and this company only then began to realize the importance of the question on account of the high price I agreed to pay.

But it happens, as I said before, that too new a question often pays for its novelty by having no existing need. And, this time, my hopes narrowly missed failing and the starting of neon lighting was very difficult. It was in Pittsburgh, at the Congress of the Illuminating Society of 1913, fifteen years ago, that I presented for the first time in America my neon tubes.

The tubes I showed on this occasion were exactly like the present tubes as to their shape, their sizes, the intensity of their light. However, I could not succeed in arousing interest in them. Soon after came the war — and this matter of neon lighting had to wait until recent years before finding its way into America.

Among the other rare gases of air, argon is furnished in appreciable quantities today from oxygen apparatus. It is used in incandescent lamps with inert atmosphere, which so curiously upset all the technical and practical conditions of incandescent lighting.

Krypton and xenon have been much more difficult to get, owing to their minute ratio in air, which does not exceed one part out of one million for krypton and of ten millions for xenon, so that the English optician Hilger charges $15 per cubic centimeter of xenon, $3,000 a gram, almost as expensive as radium. Two months ago, however, I was able to inform the Academy of Sciences of Paris that, after fifteen years of effort, I had at last succeeded in extracting these gases in good quantities and, according to my program, in a continuous operation from one of my oxygen apparatuses. My process already obtains 40 per cent of the total amount of krypton and xenon contained in the air which passes through the apparatus. This apparatus treats 25,000 cubic feet of air per hour, so I am in a position to obtain 1 liter of xenon per day. The result is important, as xenon and krypton, being extremely curious gases, will not fail to find interesting uses; all the more so that, as I remarked, dissolved gases of water, which our future plants of energy from the sea will liberate in immense quantities, probably contain five times more xenon and krypton than atmospheric air and will be able to give them in large quantities.

This technic of liquefaction of air is so fertile that I soon thought it worthy to be extended to other gases. As early as 1903 I studied its application to extracting hydrogen from gaseous mixtures—which is another example of a simple application of the properties of matter. Expansion of the compressed mixture produces cold, as usual; hydrogen, very refractory to liquefaction, remains gaseous, while all other components are either liquefied or solidified. Nothing could be simpler, in theory at least.

When I started these studies in 1903, hydrogen had few or no applications, but suddenly it acquired enormous importance owing to the work of Nernst and Haber on synthesis of ammonia.

It is well known that it was because of its advance in this respect at the beginning of the war that Germany withstood the efforts of the Allies for so long a time; no example is more poignant of the formidable power of science than the example of this miserable reaction of the laboratory, so long unable to produce even a trace of ammonia and then suddenly acquiring such an importance that it came within a hair's breadth of changing the fortune of the war.

I now wish to discuss in a few words my latest preoccupation, the development of thermic energy from the sea. It is hardly necessary for me to say that for modern humanity cheap energy is a question of life or death. Without energy nothing can be done, and engineering, in one of its most important features, is a perpetual struggle to save this energy by better and better efficiency. Nevertheless, our consumption of energy increases alarmingly and in spite of a recourse every day more intense to hydraulic forces our precious resources of coal and petrol will certainly not last more than a few centuries. Therefore, it is time to think about other sources to replace them. This would be easier if these new sources could possibly give energy at lower price than the present ones; in other words, if they could be of interest not only for our heirs, but for ourselves at the present time.

Such is the result which M. Boucherot and myself believe possible.

Most of the people who have thought about the question have concluded that among unemployed sources of energy of today only solar heat is worth while. According to Hirn the solar radiation falling on our earth is theoretically not less than sixteen hundred thousand horse power per square mile. Allow only a 1 per cent efficiency utilization process and look at the result! But, how to utilize this energy with the necessary regularity and continuity, in spite of clouds and nights, is a problem even in tropical regions. To answer these questions and see how it would be possible to obtain motive steam by means of the sun, I went to the Sahara in 1924. I soon perceived that even in these torrid regions one could not hope to get steam under pressure, in the common sense of the word, that is, under an absolute pressure surpassing one atmosphere, corresponding to water boiling at 100° C. However, you know that water easily boils at any temperature below 100° in a boiler under reduced pressure from which the steam is continually removed as fast as it is produced by the suction of a condenser in which this steam is condensed by colder water. This steam, under a pressure of one atmosphere, can very well run a turbine on its way to the condenser. All this is well known and industrially used, with steam at pressures of no more than 0.8 and 0.7 atmosphere, but I have been led to extend this possibility far below what was supposed possible.

During my stay in the Sahara, a happy misfortune sent me rain rather than sun. This caused me to think that even in these countries it would be wise not to rely upon boiling temperatures above 60° or 70°. So, little by little, I accustomed myself to the idea of using steam at lower and lower absolute pressure. And, when thinking one day of the remarkable fact that deep sea temperature is everywhere, even in the tropics, near the freezing point, while the tropical sea surface water remains uniformly above 25° C., an idea occurred to me that I should have considered foolish had it not been this progressive training. The idea was

(*Continued on page 26*)

Down in Davy Jones' Locker

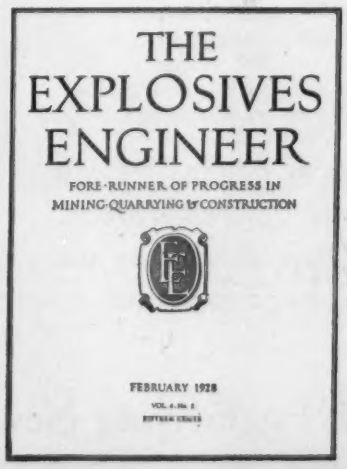
Barnacle covered, half buried in the sand of Davy Jones' locker lies the menacing hulk of a sunken ship. A menace to ocean traffic, it must be destroyed. Another task for dynamite.

Frequently sand and coral must be blasted away from the sides before dynamite can be placed to break the hull. Gelatin dynamite impervious to water is used. Divers place it at strategic points, prime it with submarine caps and fire it by electric current. The dangerous hulk is destroyed.

Explosives clear the way for progress.

The Explosives Engineer is recommended in many colleges as supplementary reading to courses in engineering.

Write for a free sample copy.



HERCULES POWDER COMPANY
(INCORPORATED)
941 King Street, Wilmington, Del.

Gentlemen:

Please send me a free sample copy of "The Explosives Engineer."

Name _____

Address _____

College _____

Ideas of An Inventor

(*Continued from page 24*)

that a difference in temperatures as 25° C. and 4° C. would be sufficient to produce steam, to condense it, and to move turbines 24 hours a day and from the beginning to the end of the year.

Appearances, however, were not encouraging.

At the temperature of 25° C., the pressure of the steam furnished by the boiling is only 0.03 atmosphere. On the other hand, the vacuum maintained by the cold water is 0.01 atmosphere. Thus, the acting difference of pressures between boiler and condenser will not exceed 0.02 atmosphere, or only $\frac{1}{750}$ that of industrial steam at 15 atmospheres. What could be expected from such conditions?

However, the Carnot formula gave me hope. This showed that $\frac{T_2-T_1}{T_2} = \frac{25-6}{298} = 6.6$ per cent to be the efficiency of a cycle performed in such conditions, which is not ridiculous at all in comparison with the 15 to 20 per cent in ordinary steam machines. The Carnot formula was true. I soon understood the reason. So small is this difference of pressures of 0.02 atmosphere that it is able to give to the steam flowing from boiler to condenser the unexpected velocity of 500 meters per second, because, in the well known formula $V=\sqrt{2gh}$, the difference of pressures h must be expressed in the height of a column of the acting fluid, which is here infinitely slight, since it weighs only 25 grams per cubic meter. Therefore the speed of this rather low pressure steam is not very much below that of ordinary steam, which does not exceed 1,500 meters per second, and is capable of moving the simplest of all turbines, the single expansion one, at the especially favorable speed of 250 meters per second. Moreover, I was led to a greater satisfaction still in perceiving that theoretically this steam would do the same amount of work as that done by the weight of surface water producing this steam falling through a distance of 300 feet. The best tide utilization corresponds to a drop of 12 feet.

Hurrying to test these amazing inferences by experience, I devised a small turbine with the help of my young cousin, Andre Claude, then introduced it into the steam current flowing from a vessel containing water at 30° C., to another vessel filled with pieces of ice to condense the vapor — and, to my joy, the turbine ran at full speed.

I informed my friend Boucherot of these results. With his help and suggestions, we elaborated our plan of harnessing the ocean, if I dare say so. The test was repeated with great success, first before the French Academy of Sciences, then in America, Canada and Cuba. The technical conditions of Cuba caused us to believe that there will be the place of our first industrial plant.

Once more then arose the song of those who, rather than acting themselves, prefer criticizing others. All the more disagreeable were these criticisms since most of them came from eminent specialists, who went as far as to deny me the right to address the public about such an imposture! Some of them argued that so small would be the work of the turbine, so important its losses by friction, that it would not start. However, I could answer like Galileo, "And yet it moves."

"Yes," retorted competent critics, "but you manage in your tests not to

(*Continued on page 28*)

THE COOP

This is the M. I. T. man's store. Here you got your freshman outfit and here you get your thesis paper and cap and gown for senior week.

It takes fifteen people to serve you through the entire year, eleven in the store and four in the Barber Shop.

This is the place that can supply you with pictures, jewelry and souvenirs that will have a permanent value to you after you have left Tech to take your place in the world.

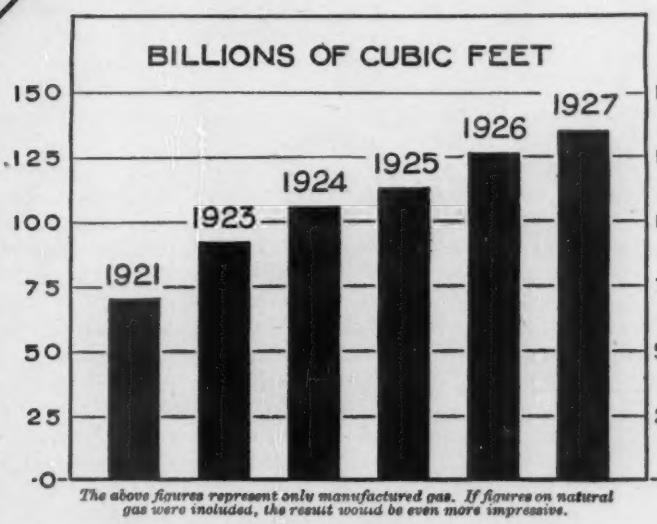
TECHNOLOGY BRANCH, H. C. S.

Have you noticed the NEW Advertisers in this issue

?

These firms believe you will be interested in their products. Write for their literature and don't forget to mention

The Tech Engineering News



The above figures represent only manufactured gas. If figures on natural gas were included, the result would be even more impressive.

GAS for Industry
—a remarkable growth

THE above graph tells a most impressive story—a story that furnishes real food for thought.

Within six short years, the sales of manufactured gas in the United States for industrial and commercial purposes have practically doubled!

Approximately 135 billion cubic feet of manufactured gas were used industrially and commercially in 1927—a staggering figure!

Today, industry is using gas for 60,000 different purposes.

Such a widespread and fast-growing acceptance of gas for industrial uses proves beyond all question the advantages and economies inherent in this superior fuel.

Industrial organizations which investigate and adopt gas, quickly note the very real benefits which accrue, and this has played a large part in the rapid advancement of gas for industrial purposes.

There are very definite ways in which gas will aid production in *your* plant and bring increased profits to you. Your local gas company will be glad to confer with you and tell you about them. Telephone or write your gas company today—no obligation will be incurred by so doing.

For free copy of book, "Industrial Gas Heat", address

American Gas Association
420 Lexington Avenue, New York City

YOU CAN DO IT BETTER WITH GAS

Ideas of An Inventor

(*Continued from page 26*)

have dissolved gases, and dissolved gases cause the whole trouble. To extract them, according to our calculations based on the practice of steam turbines, you will spend 400 per cent of the energy of the turbine." Now, to appreciate how impassioned objectors may make fools of themselves, let me say that those terrific losses amount not to 400 per cent but to 7 per cent!

Some others questioned the tightness of the apparatus for such a vacuum. Others asserted that cold water from the depths would arrive entirely heated at the surface, etc. In short, it was a complete smashing of our proposals, for in spite of the past of both Boucherot and I there were very few who, like your *Scientific American*, admitted that if this proposal could startle engineers, our past achievements ought to make them give us credit.

So strong was this opposition — so true is it that objectors are too often the wreckers of progress — that I stopped all my efforts to organize a company, and decided not to go ahead before having proven our ideas at my own expense. This proof was given at Ougree in Belgium, in which a turbine of 60 kilowatts was successfully moved at 6,000 revolutions per minute by the action of a difference of temperature of 18° C. I have now but to prove that the difficulties of the installation at the sea are equally open to solution. For that purpose, I plan to have my Ougree plant transported to Cuba, where these ideas have met with the most cordial response and to connect this plant with the cold depths by a convenient pipe as soon as I have ascertained the submarine currents, temperatures and depth conditions in the vicinity of Havana, which I am now doing.

After that I shall probably be in a position to pass to the realization of the first of our industrial plants, which shall be a 12,000 kilowatt installation.

A Pneumatic Device for the operation of snow plows attached to trucks or buses has been perfected by an eastern company.

The ordinary hoist is replaced by an air cylinder. Air is supplied by the air brake system or by air compressors attached to the timing gear box of the motor. When the air is shut off the lift chain is automatically locked.

Train Control

(*Continued from page 11*)

track. The engineman is constantly advised of the conditions along the track by means of visual and audible signals in the cab. If a train is running in a caution or in a stop block, the cab signals will so indicate, and if the track conditions are changed at any time so that either a less restrictive or a more restrictive indication is to be given, this is shown by the lights in the cab and an audible signal calls attention to the change. If a more restrictive indication is displayed, it is necessary for the engineman to acknowledge it in order to avoid an automatic application of the brakes.

Intermittent control has been adopted to a larger extent than continuous, the figures for track mileage equipped being about as follows: intermittent, 13,500 miles; continuous, 6,500 miles. Approximately 5,200 locomotives have been equipped for intermittent control territory and 3,100 for continuous territory. Cab signals are in use on all continuous control installations. The Santa Fe, Chicago and Northwestern and the Illinois Central are operating 1,700 miles of track without wayside signals, except at certain essential loca-

(*Continued on page 30*)

VENUS PENCILS

VENUS

17 BLACK DEGREES 3 copying

The largest selling QUALITY *pencil in the World*

WHETHER it be the building of a battleship, or the design of a simple household article, the pencil is the *first* requirement—the VENUS the *first pencil.*

Plain Ends $1.00 a doz.
Rubber Ends $1.20 a doz.

At all dealers

American Lead Pencil Co.
Dept. M1, HOBOKEN, N. J.
Makers of UNIQUE Thin Lead Colored Pencils. 20 colors—$1.00 per doz.

There is a *Tycos* or *Taylor* Temperature Instrument for every purpose

Taylor Instrument Companies
ROCHESTER, N. Y., U. S. A.

THE SIXTH SENSE OF INDUSTRY

Tycos Temperature Instruments
INDICATING - RECORDING - CONTROLLING

Aerial View of Chicago, Ill.

The Metropolitan City of the West

CHICAGO is a wonder city. It has grown like the proverbial mushroom—prairie giving place to pavement and tall buildings rising on every side.

The Otis organization has contributed in no small degree to this amazing record of growth. In keeping with the fact that "most of the famous buildings of the world are Otis-equipped" Chicago's major commercial structures reflect the trend toward safe and speedy Vertical Transportation with maximum safety.

State Street, Broadway, Picadilly—every famous street throughout the world—is lined with buildings wherein Otis Elevators are giving daily service in a safe, trouble-free manner—concrete examples of this company's determination to build nothing but the best—and the best is none too good to bear the world-famous Otis trade mark.

OTIS ELEVATOR COMPANY
OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD

Automatic Train Control

(*Continued from page 28*)

tions, the cab signals furnishing the engineman all the information he needs.

TYPICAL INSTALLATIONS

Intermittent Type

The accompanying table shows the status of automatic train control on July 1, 1928, classified as to type and extent of control. The mileage now equipped (February 1, 1929) has increased by about 500 miles to a total of over 20,000 track miles. From this table it is seen that the intermittent type with the inert wayside element represents 55 per cent of the total installations. This type is automatic train stop without speed control features.

The following description is typical of all installations of this class. The inductor (inert wayside element) consists of a U-shaped magnet with laminated cores and large pole pieces. It is located on long ties with its pole faces 2½ inches above the top of rail and with its center line parallel to and about 20 inches outside the gage line. The receiver, which is carried on the engine tender, consists of an inverted U-shaped magnet with laminated cores, large pole pieces and two coils. The faces of the pole pieces of the receiver and of the inductor are about 2 inches apart as they pass. Figure 2 shows the inductor and the receiver; in some installations the receiver is attached to the side truck frames instead of the journal box.

The principle of the inductive control is illustrated by diagram (Fig. 3). When the signal is at clear, the choke coil on the inductor is closed on itself, and when the signal gives a restrictive indication, this coil is on open circuit. One of the coils on the receiver, the "primary coil," being constantly energized by current from the electric headlight generator, produces a strong magnetic field. The other coil, the "secondary," is connected to the same source of energy and in series with the coil and front contact of relay, R-1. When a train approaches a signal indicating either caution or stop, the locomotive receiver passes over a wayside inductor which is on open circuit, and a surge of magnetic flux builds up in the secondary coil and produces a negative current sufficient to allow the primary relay to open, and being a "stick" relay it remains open until restored. The opening of the relay deënergizes an electromagnetic valve which controls the actuator, the brake applying apparatus. When thus deënergized, the electropneumatic valve allows air to move the actuator piston, which in turn operates the engineman's brake valve for a service application of the brakes. If, however, the engineman acknowledges as the locomotive passes the inductor, this action maintains current through the electropneumatic valve and the brake actuator is not operated. It is ordinarily designed so that the acknowledging lever may be held over for about 15 seconds when passing an inductor, and a whistle sounds in the cab when the inductor has been passed. If the acknowledging lever is held over beyond the allowed time an automatic brake application will result. Figure 4 shows the actuator applied to the engineman's brake valve.

When a train approaches a signal at clear, the locomotive receiver passes over an inductor which is on closed circuit and there is not sufficient induced current to open relay R-1, and the electropneumatic valve remains energized.

In the magnetic intermittent system (used on about 1,400 miles of track) the wayside element is a permanent magnet, usually placed on the ties between the rails. When the signal is at caution or danger the track magnet releases magnetically-held valves on the locomotive tender and a service application of the brakes will result. If, however, the signal is at clear, electromagnetic coils at the track magnet neutralize the field of the permanent magnet and the magnetically-held valves on the locomotive receiver are not released. With this system there are no electrical circuits maintained on the locomotive for the operation of the receiving apparatus.

The only other type of intermittent train control is the electrical contact (ramp) which has previously been discussed.

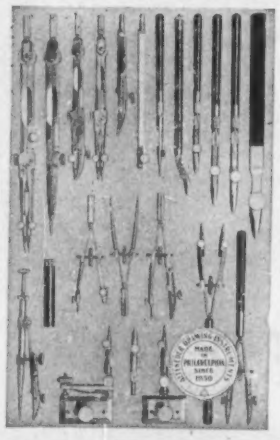
Continuous Type

Continuous inductive systems of train control require the establishment of alternating current circuits in the track so controlled that the receiving apparatus is affected in different ways depending on the track conditions. Space does not permit complete descriptions of the various systems — stop, 2-speed and 3-speed; but the essential features will be given.

The transmission of control from the track to the locomotive receiver is accomplished by making use of the magnetic fields established around the rails by the alternating current (train control) circuits in the rails. This magnetic field excites the locomotive receiving apparatus which in turn excites the amplifying apparatus. The amplifier energizes the primary relay which controls the brake applying apparatus. Where the installation includes speed control, the mechanism for measuring speed and distance is interposed between the control received from the track and the brake applying apparatus.

The important features of the locomotive equipment are receiver track and loop coils, relay, amplifying unit, dynamotor, brake applying apparatus, cab signal, acknowledging lever, reset device; and in the case of speed control, a centrifugal governor for measuring speed, cams for measuring distance and electrical contacts jointly operated by the governor and cams. Figure 5 shows the equipment case which houses the relay and other electrical apparatus. This apparatus is really the "heart" of the train control in the continuous system. The equipment case is usually carried on the locomotive. Figure 6 is a view of the interior of a locomotive cab (on the engineman's side) on a Union 3-speed continuous installation on the Santa Fe. In this view it will be noted that three-position cab signals are used. On automatic stop systems (without speed control) the cab signal usually gives but two

(*Continued on page 32*)



GIFTS

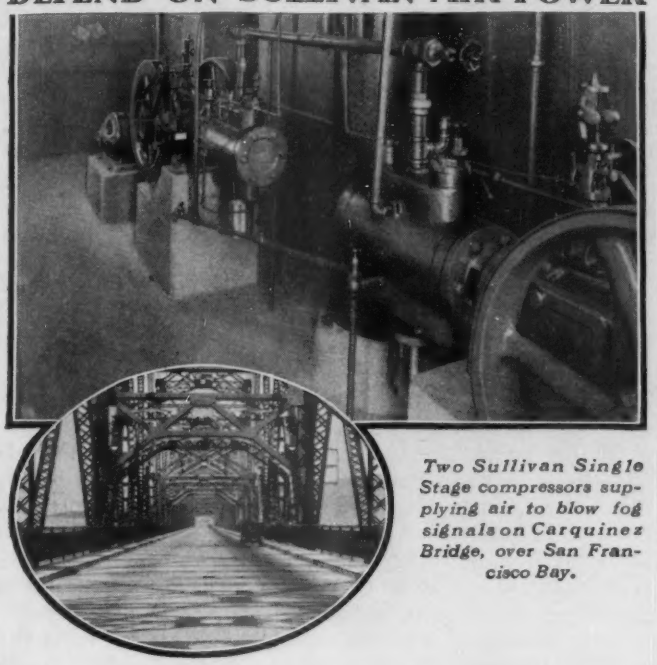
Fine tools are priceless gifts. The man who uses drawing tools will prize one made by *Alteneder.*

Send for Gift Circular

THEO. ALTENEDER & SONS

1226 Spring Garden Street, Philadelphia

DEPEND ON SULLIVAN AIR POWER



Two Sullivan Single Stage compressors supplying air to blow fog signals on Carquinez Bridge, over San Francisco Bay.

Air Signals Guard Longest Highway Bridge

When fog blankets San Francisco Bay, ships pass the great Carquinez Bridge in safety. For fog signals blown by Sullivan Air Compressors sound warning from the center pier.

The structure is 460 feet high, and ships glide easily underneath, but the massive center pier is a dangerous obstacle in the darkness.

Soon after construction of the bridge got under way the need arose for fog signals. Investigation revealed Sullivan single stage belt driven compressors giving excellent service at various lighthouses along the coast. And similar machines were selected for the bridge.

This $8,000,000 structure is 4482 feet long. Four motor trucks can travel abreast on the roadway which lies between the sidewalks. And more than a million cars speed over it annually.

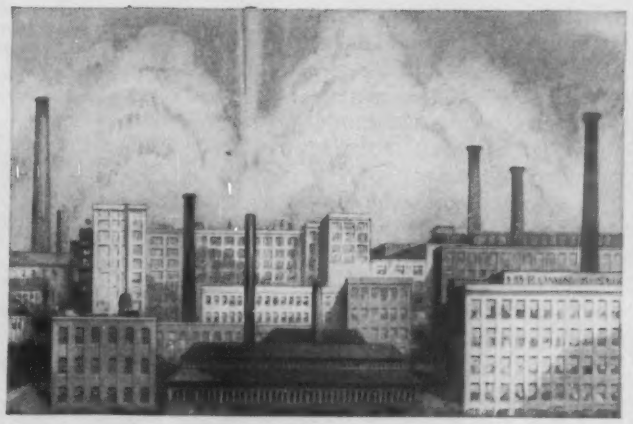
Carquinez Bridge is only one of countless enterprises making use of the dependable air power supplied by Sullivan single stage and two stage compressors.

Catalogs will be sent on request.

Send also for the booklet outlining your opportunities if you should join the Sullivan organization.

SULLIVAN MACHINERY COMPANY
164 S. Michigan Ave., Chicago
Offices in all principal cities of the world

SULLIVAN TRADE MARK



A Mechanical World in Itself

THOSE who go through the Brown & Sharpe plant very frequently come out with the impression of having visited a mechanical world in itself.

Every facility exists in this plant for making Brown & Sharpe Milling, Grinding, Gear Cutting and Screw Machines, as well as Cutters, Machinists' Tools, and miscellaneous Shop Equipment.

These products are used all over the world and have set a standard of accurate performance that is recognized by shop men everywhere.

We are always ready to send literature describing any of our products to students who are interested.

BROWN & SHARPE
BROWN & SHARPE MFG. CO. B&S PROVIDENCE, R. I., U. S. A.

Automatic Train Control

(*Continued from page 30*)

indications, red or green. A long blast of a whistle is sounded when the cab signal changes from green to red and a short blast when the change is from red to green, giving ample warning for the engineman to operate the acknowledging valve.

The general method of control between track circuits and locomotive receivers is described in the following excerpt from an article on the Union 3-speed system on the Santa Fe, which appeared in the *Railway Age* of August 6, 1927:

In the "track circuit" a transformer feeds current down one rail through the track relay, or the axles of any train which may be in that particular section, and back through the other rail. In the "loop circuit" the current travels down both rails in multiple (the same direction under the train). At the end of the track section the currents in the rails are brought together and return over a wire installed on the pole line.

The "track receiver," being at the front of the locomotive, picks up the track current energy before it is shunted by the wheels. The "loop receiver," being mounted on the rear end of the tender, is out of the zone of track circuit current because this has been shunted through the wheels of the locomotive. The coils of the "loop receiver" are connected in such a manner, however, that the voltages induced in them are additive for currents passing through both rails in the same direction, and hence are affected solely by the "loop circuit" current.

The "high speed" indication is established when the track is unoccupied for a specified distance ahead. It is brought about by energization of both the "track circuit" and the "loop circuit" with the *normal* direction of current flowing in each circuit. The "medium-speed" indication is established when the track is occupied at a specified distance ahead. This is brought about by energization of both the track and the loop circuits but with the current in the latter circuit *reversed*. The "low-speed" indication is established when the track is occupied at a specified shorter distance ahead. This is brought about by deënergization of either the "track circuit" or the "loop circuit."

In the Santa Fe installation described above, the maximum speed limits are as follows:

Speed	*Passenger*	*Freight*
H	65 m. p. h.	45 m. p. h.
M	40 m. p. h.	30 m. p. h.
L	20 m. p. h.	20 m. p. h.

When a train running under H indication (Fig. 6 shows this type of cab signal) exceeds the speed limit, an automatic brake application will be made in five seconds, and if the engineman promptly laps his brake valve, the application will cease when the speed has been brought slightly below the high-speed limit. If the cab signal indicates a change from H to M, an automatic brake application will be made after a short "blow-down" period if the train is running above the medium speed limit, the application being avoided if the engineman brings the speed down below the medium speed limit during the "blow-down" period. An automatic brake application will occur whenever a change from H to L or from M to L is indicated unless the change is acknowledged and the train speed brought down below the low-speed limit before the end of the "blow-down" period.

Code System

The most recent development in continuous control is the "code" system, which it is claimed has all the advantages of the other types, but which may be used in connection with A. C. and D. C. track circuits and on tracks carrying A. C. or D. C. propulsion current. Briefly, this system is as follows: the locomotive carries a master relay which is controlled by energy from the track circuit in which a "coder" (code transmitter) is connected across the rails at the exit end of the block. The coder consists of a small motor revolving a series of cams so arranged that the current fed into the track may be

(*Continued on page 34*)

OKONITE

SINCE 1878
The
STANDARD BY WHICH QUALITY IS JUDGED
in all forms of
RUBBER INSULATED WIRE AND CABLE
VARNISHED CAMBRIC WIRE AND CABLE
IMPREGNATED PAPER CABLE
AND TAPES
Manufactured by
THE
Okonite Company
The Okonite-Callender Cable Co., Inc.
501 FIFTH AVENUE, NEW YORK, - N.Y.

Eyes
gods would envy
—you can command them in any laboratory

OPTICAL instruments today continually open new worlds of all-powerful "little things" for scientists to rule over.

In industry this added mastery is becoming more and more important. To develop new processes—to speedily control old—to insure at every step the precision mass production must have, optical science puts at the engineer's command a host of convenient, accurate instruments specialized to the need.

Bausch and Lomb scientists have studied the problems of production in many fields. They are always at your command. Call on them.

BAUSCH & LOMB OPTICAL CO.
635 St. Paul St., Rochester, N. Y.

MATHEWS FIRE HYDRANTS

CAST IRON PIPE

Sand Spun or Sand Cast for Gas and Water

FITTINGS

FOUNDRIES AND WORKS, FLORENCE, NEW JERSEY

Gate Valves and Boxes

Hydraulic Tools, Valves Fittings

Gas Producers

Gas Machinery

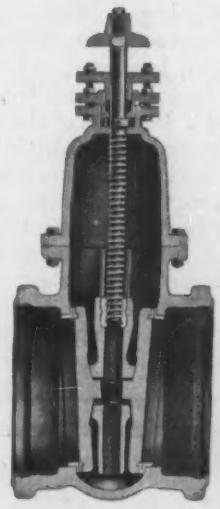
THE "MATHEWS" FIRE HYDRANT dates back to the late sixties, when Hydrants were largely the product of local foundries and the designs many and varied.

"MATHEWS" immediately gained favor and rapidly became the STANDARD for COMPARISON.

Today, with over three hundred thousand in service, it occupies first place, and the long list of users is constantly growing.

Our long experience has brought steady improvement in the details of construction, but because of the fundamentally sound principle there has been no radical change in the essential features of design. Correct design and substantial construction account for the success of the "MATHEWS" Hydrant.

We extend an invitation to all interested students to visit our extensive plant to observe the manufacture of "MATHEWS" Hydrants, and our other products.



CAST CENTRIFUGALLY IN SAND MOLDS

R. D. WOOD & COMPANY

Engineers, Iron Founders, Machinists

PHILADELPHIA, PENNSYLVANIA

Automatic Train Control

(*Continued from page 32*)

interrupted a prescribed number of times per minute, depending upon the track conditions in advance. This coded current is transmitted to the master relay on the locomotive which selectively energizes the proper decoding relays and controls the cab signal indications. The codes used on the Pennsylvania Railroad are as follows: Clear, 180 per minute; approach restricting, 120 per minute; approach, 80 per minute; caution-slow speed, steady current or absence of current. These can be modified if the approach restricting indication is not desired. Any change in track conditions occurring which causes the cab signal to give a more restrictive indication will initiate an automatic brake application unless the change of cab signal indication is promptly acknowledged by the engineman.

Present Status

The Interstate Commerce Commission recently completed an investigation relative to automatic train control and on November 26, 1928 announced its decision not to require further installations at the present time. In its report the Commission discusses two principal factors: (1) the present status of automatic train control and (2) the relation of train control to other means of increasing safety in railway operation.

The Commission finds that train control has proved to be practicable and that certain difficulties encountered when the installations were first made are now being eliminated as the result of increased experience. Lack of standardization, however, is found to be a serious handicap, particularly at joint terminals. Because of the different systems adopted there is little interchangeability and it is necessary to equip many locomotives with apparatus of two types in order that they may be operated on the tracks of other railroads and at terminals.

The Pennsylvania Railroad is planning to equip two hundred twenty-five locomotives for operation with continuous cab signals but without the automatic stop; the "code" system will be used. These cab signals give four indications. Two signals will be placed in each cab, one for the engineman and one for the fireman. The Pennsylvania is fully convinced that cab signals of this type offer great possibilities for increased safety and efficiency in train operation. The Commission refers to this as an important forward step in the art of signaling and worthy of special attention.

In its study of the relation of automatic train control to other means of promoting safety the Commission finds that in the five-year period from 1923 to 1927 inclusive, 11,485 persons were killed in grade crossing accidents in the United States, and during the same period 885 persons were killed in derailments and 579 in collisions. In 1927, 2,371 persons were killed in grade crossing accidents. In that year there were only three collisions in which passengers were killed, and the total number of passengers killed in such collisions was six. It is evident that automatic train control would not have prevented all the collisions nor many of the derailments. The railroads have spent $26,000,000 so far in the installation of train control on 20,000 miles of track and 8,300 locomotives. The number of accidents which might have occurred is problematical. The railroads spent about $92,000,000 from 1920–1926 in the elimination of 3,600 crossings. At the present time there are 235,000 highway grade crossings in this country. To abolish them all would be impossible; the cost would be staggering. But with proper coöperation between the railroads and municipal and state authorities, progress can be made in the elimination of some of the crossings and in the reduction of the hazards at many of the others.

After considering these matters, the Commission decided that it would not require further train control installations at the present time but the carriers were urged to be diligent in their efforts to provide adequate protection against accidents due to grade crossings, derailments, collisions in territory not protected by block signals, failure of wooden bridges and trestles, and the use of wooden passenger cars. The railroads are expected to undertake the necessary studies and tests to bring about standardization of train control devices so that they may be used in terminal areas and on joint tracks where traffic density is greatest without the necessity of expensive and inconvenient duplication of locomotive or wayside equipment.

William G. Starkweather, M. E., Cornell '92 John B. Starkweather, B. S., M. I. T. '21

STARKWEATHER & BROADHURST
INCORPORATED

Engineers and Contractors for Power Plant Apparatus

79 Milk Street BOSTON Telephone, HANcock 4530

Departmental Notes

(*Continued from page 20*)

in sanitary engineering at the Institute. This plan makes available for the sanitary engineering work at the Institute the resources of a laboratory, within reasonable distance of Cambridge, built and operated in a way no college laboratory could hope to emulate.

On February 19 and 20, the third two-day conference for Master Plumbers will be held at the Institute under the auspices of the Department of Civil and Sanitary Engineering. At this conference members of the Institute staff will discuss problems pertaining to the engineering and administrative aspects of the plumbing trade, together with the problems associated with materials used and construction. These conferences, which have been held annually since their inception, have been very well received by the plumbing trade and favorably commented upon by the plumbing press all over the country because of the high standard and generally beneficial character of the lectures and laboratory demonstrations. The average attendance has been from 400 to 500.

CHARLES M. SPOFFORD.

A New Mechanically-Operated Brake has recently been announced by a mid-western company. This brake is a shoe-type and is intended for the bridge drives of electric traveling cranes, lift bridges, electric hoists, and other applications requiring foot-operated or hand-lever operated brakes.

It is a modification of the company's electrically-operated Type W B body, practically all the wearing parts of the new mechanically-operated brake being interchangeable with the former electrically-operated brake. It is equipped with unusually thick molded asbestos brake shoes requiring renewal only after very long periods.

Wherever Wheels and Shafts Turn

The swift strides made by Timken through long research and large resources have placed Timken Bearings in the forefront of the economics of a mechanical age.

Daily new uses are found, new applications, new advantages, and daily Timken sweeps to new peaks.

At every turn—in industry, transportation, mining and agriculture—Timken Bearings are at work in railroad and street car journals, motor cars, buses, trucks and machinery of all kinds, opposing friction with anti-friction, waste with saving.

Wherever power is applied through moving parts, Timken Bearings are bettering the work of the world—holding friction in check, carrying radial and thrust loads, resisting wear, cutting production costs and increasing production wherever wheels and shafts turn.

"Timken-Equipped" and its practical application should be carefully followed by every student of proper power transmission.

THE TIMKEN ROLLER BEARING CO., CANTON, OHIO

TIMKEN

Tapered

ROLLER BEARINGS

Modern Freight Transportation

(*Continued from page 13*)

In the electropneumatic type the air-operating cylinder is mounted parallel to the track. The air pressure is controlled by electrically operated valves and is transmitted by a "live-lever, dead-lever" arrangement similar to the foundation brake gear of a freight car, through bell cranks and springs to the retarder shoe. The pressure is graduated in four steps, and release is accomplished pneumatically.

To take care of wheel-dimension variations very heavy springs are used in the final transmittal of pressure to the shoes. Ample margin is provided so there is no danger of their breaking when subjected to heavy duty service.

The general practice in handling cars is to set the proper degree of retardation in each retarder before the car reaches it, as this requires less current, and also causes less wear on the parts.

The control machine consists of a compact steel cabinet with a sloping top divided into panels, which can be raised for the inspection of the apparatus. On each panel there is provision for retarder levers, switch levers, lever lights, and the name plates for the levers. Each machine has levers for the particular requirements of the track layout and retarders. The lever lights, when illuminated, show the operator that the retarder has operated to the corresponding position of the retarder lever.

Small lights, usually placed just above the switch lever, indicate the normal and reverse positions of the track switches. Where track circuits are used, there is a light for each one which indicates whether a car is on the circuit. With track circuits it is impossible to throw a switch under a car. In the lower part of the cabinet is a terminal board with panels, on which are mounted the main switches, bus bars, fuses, and terminals.

There is usually one lever machine in each control tower, but where two operators work during peak hours, two lever machines of half the size are provided. In most yards two or three control towers are adequate. The towers should afford a clear view in all directions of that part of the yard controlled by each, so that the operator may observe the speed of the cars and their relative positions.

The power equipment varies according to the commercial current available and the specifications of a particular railroad. In case of failure of the commercial current, the load is automatically switched to a storage battery, which will operate the plant for some time. The power plant for the electropneumatic type consists of compressors, usually motor-driven, and 6-volt battery circuits for the control. The air capacity is not determined by the number of retarders, but by the number of switch and retarder movements.

The power required varies with the number of cars handled and other conditions. Figures obtained from one of the first retarder installations show approximately .04 kw.-hr. per car. Assuming that 1,000 cars are handled per day and that current costs $.03 per kw.-hr., the monthly cost of power would be approximately $37.20.

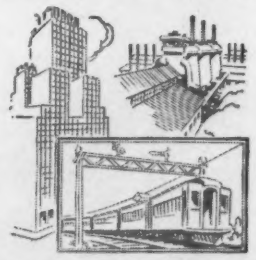
The switch machines which operate the track switches are similar to the switch machines used in electric interlocking, the difference being that some of the safety features not required for low-speed yard operation have been eliminated. The operating time is about one second, which is well under any requirements. The machines are either electropneumatic or all-electric.

(*Continued on page 38*)

Steel Sheets

That Resist Rust!

Highest quality steel sheets for the engineering, railway, industrial and general construction fields. This Company is the largest and oldest manufacturer of Black and Galvanized Sheets, Blue Annealed Sheets, Keystone Rust-resisting Copper Steel Sheets, Roofing Products, Culvert Stock, Tin and Terne Plates, Etc., for all uses. Sold by leading metal merchants. Send for booklets.



AMERICAN

STEEL SHEETS *for* Every Purpose

Manufactured by

American Sheet and Tin Plate Company

SUBSIDIARY OF UNITED STATES STEEL CORPORATION

GENERAL OFFICES: FRICK BUILDING, PITTSBURGH, PA.

DISTRICT SALES OFFICES:—CHICAGO, CINCINNATI
DENVER, DETROIT, NEW ORLEANS, NEW YORK
PHILADELPHIA, PITTSBURGH, ST. LOUIS

Export Representatives—U. S. STEEL PRODUCTS CO., New York City
Pacific Coast Reps.—U. S. STEEL PRODUCTS CO., San Francisco
Los Angeles, Portland, Seattle, Honolulu

CONTRIBUTOR TO
SHEET STEEL
TRADE EXTENSION COMMITTEE

BAILEY METERS

Used by Leaders in Every Industry

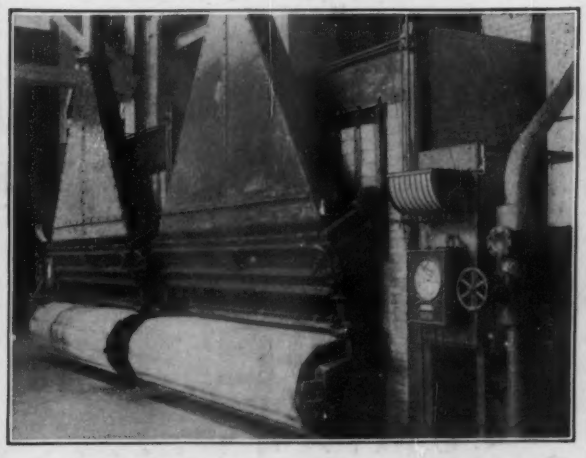
BAILEY METERS, already so firmly established in the Central Station Field that they are standard equipment in more than 90% of the up-to-date plants, are now being used more and more by the leaders in every line of industry—where they are reducing the losses, improving combustion conditions and providing accurate, reliable and trustworthy data for accounting systems.

BAILEY PRODUCTS

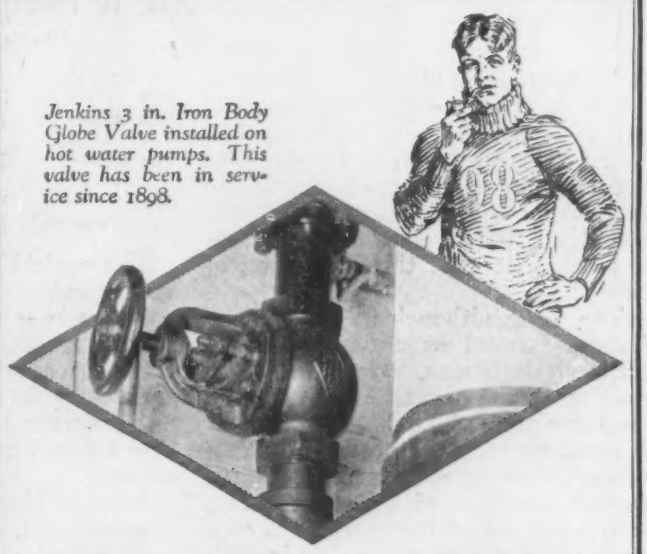
Automatic Control	Liquid Level Gages
Boiler Meters	Manometers
Coal Meters	Multi-Pointer Gages
Draft Gages	Pressure Recorders
Fluid Meters	Tachometers
Gas Flow Meters	Temperature Recorders
Gravity Recorders	V-Notch Weir Meters

Write for Bulletin No. 81B

Bailey Meter Co.
Cleveland, Ohio



Bailey Meters at Western Electric Co., Kearney, N. J.



Jenkins 3 in. Iron Body Globe Valve installed on hot water pumps. This valve has been in service since 1898.

A Jenkins Valve "Class of '98"

This Jenkins 3" Iron Body Globe Valve was made in 1898 and has seen continuous service since that time in the New York City works of R. Hoe and Co., Inc., world's largest manufacturer of printing presses. The photograph, which is unretouched, shows the valve installed on hot water pumps. This valve is one of a good-sized number of Jenkins "Class of '98" valves in use at the Hoe plant.

The performance of these "ninety-eighters" can be matched in hundreds of industrial installations throughout the country where veteran Jenkins Valves are on the job. Instances are not uncommon of Jenkins Valves which are still in service after thirty, thirty-five and even forty years.

There's a Jenkins Valve for practically every power plant, plumbing, heating and fire protection requirement. Jenkins Valves are furnished in bronze and iron, in standard, medium pressure and extra heavy types.

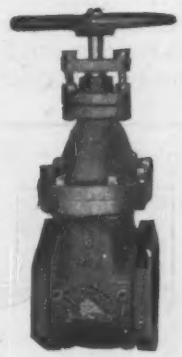


Fig. 325
Screwed, Jenkins Standard Iron Body Gate Valve

Send for a booklet descriptive of Jenkins Valves for any type of building in which you may be interested.

JENKINS BROS.
80 White Street.....New York, N. Y.
524 Atlantic Avenue.....Boston, Mass.
133 No. Seventh Street....Philadelphia, Pa.
646 Washington Boulevard....Chicago, Ill.
JENKINS BROS., LIMITED
Montreal, Canada London, England

Always marked with the "Diamond"
Jenkins Valves
SINCE 1864

Modern Freight Transportation

(*Continued from page 36*)

It is the practice of some railroads to install detector track circuits at each switch to prevent the throwing of a switch under a train, essentially the same as in interlocking practice. However, this has a tendency to slow up operation. With well-drilled operators it is not felt that this protection is needed.

The skate, although solely a safety feature, is used on a number of retarder installations, being placed on each track just beyond the frog at the clearance point. The skate is used only in emergency to stop a car. It consists of a steel casting with its upper surface curved, the base of the skate fitting into a supporting frame which is connected to a simple mechanism in such a manner that the skate is raised from its normal position beside the rail to a vertical position on the rail.

Engine movements in the yard are controlled by one or more color-light signals, each of which indicates in both directions. One signal is located usually at or near the crest of the hump, and is controlled by the hump engine conductor. The aspects and indications vary among the railroads, but the following are typical:

Color	*Indication*
Red	Stop
Yellow	Proceed at normal humping speed
Two yellow	Proceed at fast humping speed
Green	Proceed at normal yard speed
Yellow over red	Back up

The control of the humping signal and repeater signals is such that the operator in the first tower can at all times cause the display of a stop indication in case of emergency, and in such cases the hump conductor must put his control lever to the stop position before he can give proceed indications.

Some of the auxiliary features in a retarder yard, and which are also used to a lesser extent in car-rider yards, are as follows:

1. Teletype system, by means of which typewritten lists of cars and their weights are transmitted simultaneously from the yard office to the hump, all towers, and other points where required. Pneumatic tubes are sometimes used for distributing lists.,

2. Loud-speaker telephone system, with transmitters and receivers at the hump and each tower, so that the hump and tower operators can communicate with each other easily and quickly.

3. Short-wave radio apparatus for communication between the conductor at the hump and the engineer of the humping engine. A trial of this system has given satisfactory results on one important installation (Selkirk Yard, New York Central), where 125-car trains are humped.

4. Flood lighting, essentially the same as in any hump yard, but arranged with respect to the view of the retarder operators.

5. Track scales, when required, the same as in any hump yard.

6. Mechanical hump, which provides means for raising or lowering the hump to compensate for the different running of the cars in winter and in summer. With a hump high enough for the worst condition, as an empty car on a cold winter day, and with sufficient retarders, a mechanical hump is unnecessary, and one has not been included in a retarder installation since 1926.

7. Hot-oil plants to apply hot oil under pressure to car journals in cold weather to cause the cars, especially

(*Continued on page 40*)

DUDLO

World's Largest Manufacturers of Fine

MAGNET WIRE *and* WINDINGS

For Every Electrical Purpose

Ask for a copy of the DUDLO folder "Wire and Winding Data." It will help you in your work

DUDLO MANUFACTURING COMPANY
FORT WAYNE, INDIANA
Division of The General Cable Corp.

LABORATORY SUPPLIES

for Industrial Plants & Educational Institutions

L. E. KNOTT APPARATUS COMPANY
Cambridge, Massachusetts

W. F. EAMES,
Design Engineer,
Carnegie Tech, '18

P. M. McCUSKER,
Headquarters Sales,
W. T. N. S., '21

C. M. PURDY,
Interdepartmental Contract Administration,
W. T. N. S., '26

YOUNGER COLLEGE MEN ON RECENT WESTINGHOUSE JOBS

R. P. JENSEN,
Construction Superintendent,
Armour Institute of Technology, '23

W. R. HARDING,
Motor Engineer,
U. of N. Carolina, '17

H. J. PETERSEN,
Control Engineer,
U. of Washington, '26

The Fisher Building

Where do young men get in a large industrial organization? Have they opportunity to exercise creative talent? Is individual work recognized?

* * *

IN architectural beauty and in completeness of accommodations for all classes of business and professional activities, Detroit's new Fisher Building has been pronounced ten years ahead of the times.

An important feature of its advanced development is the Westinghouse elevator system which serves the 26-story tower and the 11-story wings. Twenty-five elevators are installed, all with automatic control which brings each car to a smooth stop exactly level with the floor every time. A master control system, in addition, enables the chief operator to advance or retard speeds from his own station and to maintain accurate service schedules.

Lighting equipment, installed under the largest contract of its kind ever placed, is equally advanced. More than 12,000 Westinghouse Sollux units give light without glare throughout the entire structure.

Pumps and ventilating fans are driven by Westinghouse motors.

The complete electrification of the Fisher Building is the sort of a job that must go to an organization large enough to handle it. Westinghouse offers young men a type of opportunity that appeals to those with enterprise and talent.

Westinghouse

Modern Freight Transportation

(*Continued from page 38*)

the light loads and the empties, to roll freely and so not delay operations.

As each cut leaves the hump, each operator sets the several switches in position to line up the respective route, and then sets each retarder at one of its four degrees of retardation — in general, heavy retardation for a heavy loaded car, and little or no retardation for an empty car. The proper amount of retardation depends on the weight and speed of a car or cut, the necessary spacing to prevent fouling of cars, and the destination of the following cuts. With cars of similar weights a close spacing can be maintained. The most unfavorable condition is a heavy load followed by an empty proceeding to adjacent tracks, as it is necessary to apply considerable retardation to the former to prevent acceleration, and to allow the empty to proceed with little or no retardation so as not to stop it on the leads and so block the yards. Such a case is properly handled by providing a suitable time interval at the hump.

After handling the cars through several retarders, they are finally let out of the last retarder at a speed of about three miles an hour on a non-accelerating grade, at which speed they may bump other cars standing on the same track without damage to cars or lading. The retarder operators become expert in handling cars under all conditions. There are records of some remarkable performances where 150 to 200 cars have been humped in an hour.

The maximum capacity of a retarder yard is attained with a group of retarders on each classification track, but the cost of such an arrangement would be very high, and the capacity afforded would be far in excess of normal requirements. It is therefore the practice to design an arrangement for the particular requirements, and as economy of installation requires a minimum number of retarders, one group of retarders usually serves from three to seven or more classification tracks, according to traffic, number of classification tracks, and other factors.

In a typical arrangement six leads radiate from the hump lead, and each lead serves six classification tracks. There are three groups of retarders: first, the hump, which controls the speed of cars at the junction switch, and is used also to space adjoining cuts; second, an intermediate group, which checks the acceleration of cars or cuts on the comparatively steep grades; and third, the final group which reduces the speed to about three miles an hour.

The principal economies resulting from retarder operation may be summarized as follows:

1. Reduction in engine and crew hours. In most yards the humping engine and crew spend only part of the time on humping operations, and the rest in making up trains, delivering transfers, or on miscellaneous switching operations. This makes it possible to effect a considerable reduction in the engine hour per day.

2. Retarder plant available for maximum traffic twenty-four hours of the day.

3. Various flat switching operations at adjacent points or at several stations can be done at the retarder yard, and often make a large reduction in engine and crew hours.

4. Elimination of car riders and switch tenders, and other employees, and of injuries to these employees.

5. Reduction in damage to cars and lading. On account of the facility of controlling cars by retarders, the humping or coupling of cars at excessive speeds is eliminated.

6. Reduction or elimination of pilferage, which is often a big item, especially at night, in a large yard with many car riders and switch tenders.

7. Reduction in labor of cleaning yards. Much coal and similar commodities are shaken from cars on account of coupling at excessive speed.

8. Reduction in the average time required to handle a car or train in the yard. This also tends to reduce the elapsed time between terminals, and thus results in more economical operation on the entire division.

9. Quicker deliveries to shippers. In several cases this has been the subject of favorable comment to railway officials by large shippers.

10. Elimination of accidents and delays resulting from defective brakes. In car-rider yards defective brakes are often not detected until after a car has passed over a hump, in which case the rider is helpless; the car crashes into other cars, damaging both cars and lading. Operations are delayed until the wreckage is removed.

The car retarder is one of the most modern time and labor devices that have enabled the railways to reduce operating expenses in spite of rising costs of labor and materials. Although the retarder is a recent development, the first commercial installation in the United States was put in service in February, 1926, and nearly all of the apparatus of the first installation is still in service. The design of this first apparatus has been substantially improved, based upon careful observations under service conditions, and the improved design, which has been in service nearly a year, amply meets all requirements, showing that the retarder has successfully passed through the development stage and is now generally considered as an approved device for the efficient and economical operation of hump yards.

Recent Books

(*Continued from page 22*)

production. Particular emphasis is laid on the standardization of specifications and the experience of the United States Government in this line is given.

International and national standardizing laboratories are also described and we regard with pardonable pride the outstanding position of our own Bureau of Standards in comparison with similar bodies in other countries.

The trend of standardization is shortly sketched and we see the major developments of our industrial age in the future.

S. F. B.

SAMSON SPOT SASH CORD

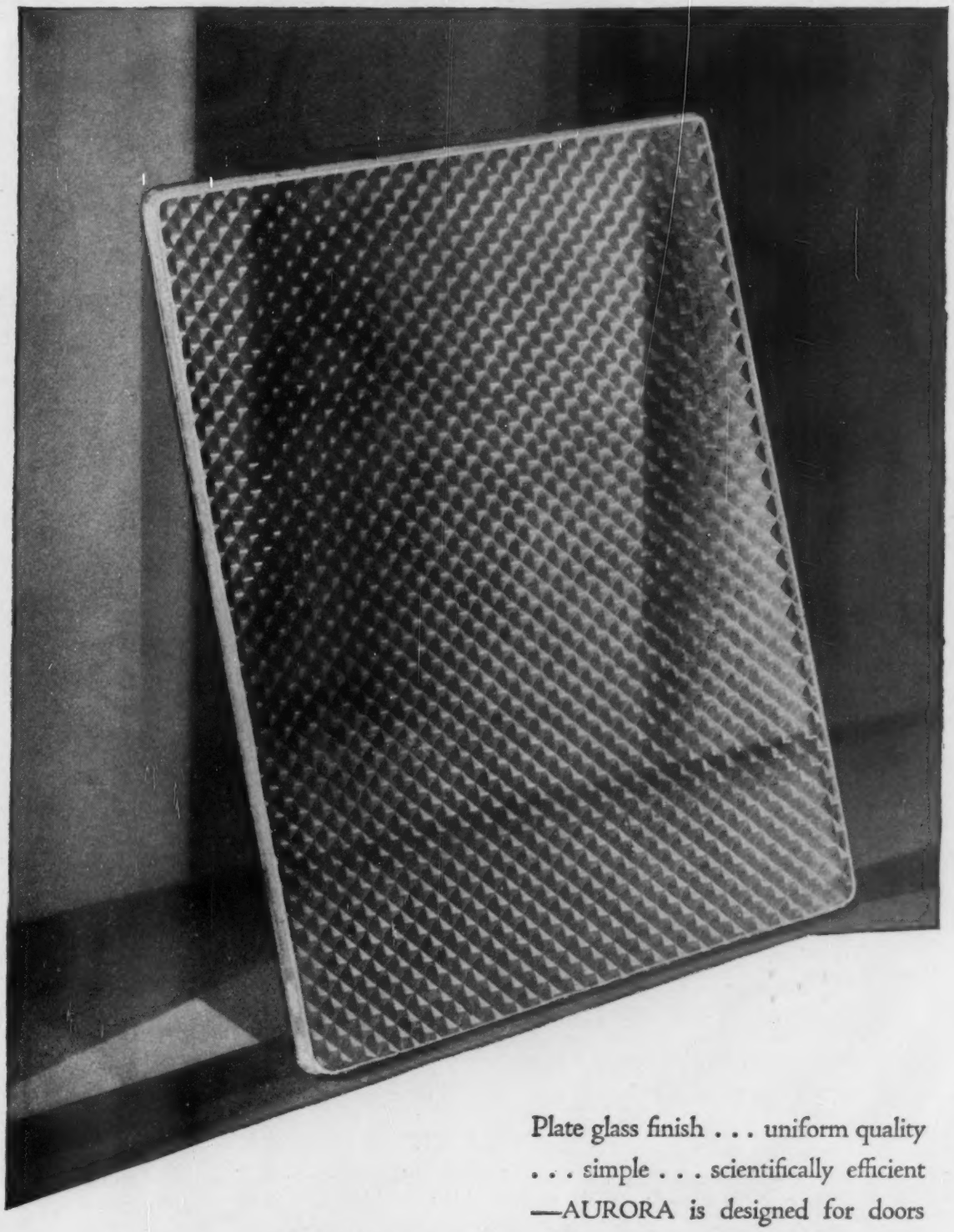
Trade-Mark Registered U. S. Patent Office

Made of extra quality cotton yarn, carefully inspected, and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.

We make braided cord of all sizes, kinds, and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.

CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST

SAMSON CORDAGE WORKS : : **88 Broad Street, Boston 9, Mass.**



AURORA
beauty and
simplicity

Plate glass finish . . . uniform quality . . . simple . . . scientifically efficient —AURORA is designed for doors and partitions in buildings where quality and good taste are emphasized without sacrificing the proper illumination demanded by modern business.

Sample upon request.

Mississippi Glass Company · 220 Fifth Ave., New York

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers Courses, each of four years' duration, in Civil, Mechanical, Electrical and Aeronautical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy and Geology; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health and Sanitary and Municipal Engineering; Mathematics, Physics, General Science and General Engineering; and in Engineering Administration. These Courses lead to the degree of Bachelor of Science.

To be admitted to the first year class applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History and French or German and two units of elective subjects. Examinations are required in all subjects except Chemistry, History and the electives, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy, Doctor of Science and Doctor of Public Health are also offered. Special Research Laboratories of Physical Chemistry, Organic Chemistry, Applied Chemistry and Science have been established.

Correspondence should be addressed to the Institute of Technology.

PUBLICATIONS

Catalogue: Bulletins of General Information, Summer Session, and Graduate Study and Research; and the Report of the President and the Treasurer.

Any of the above named publications will be mailed free on application.

For information address

ADMISSIONS OFFICE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE A, MASS.

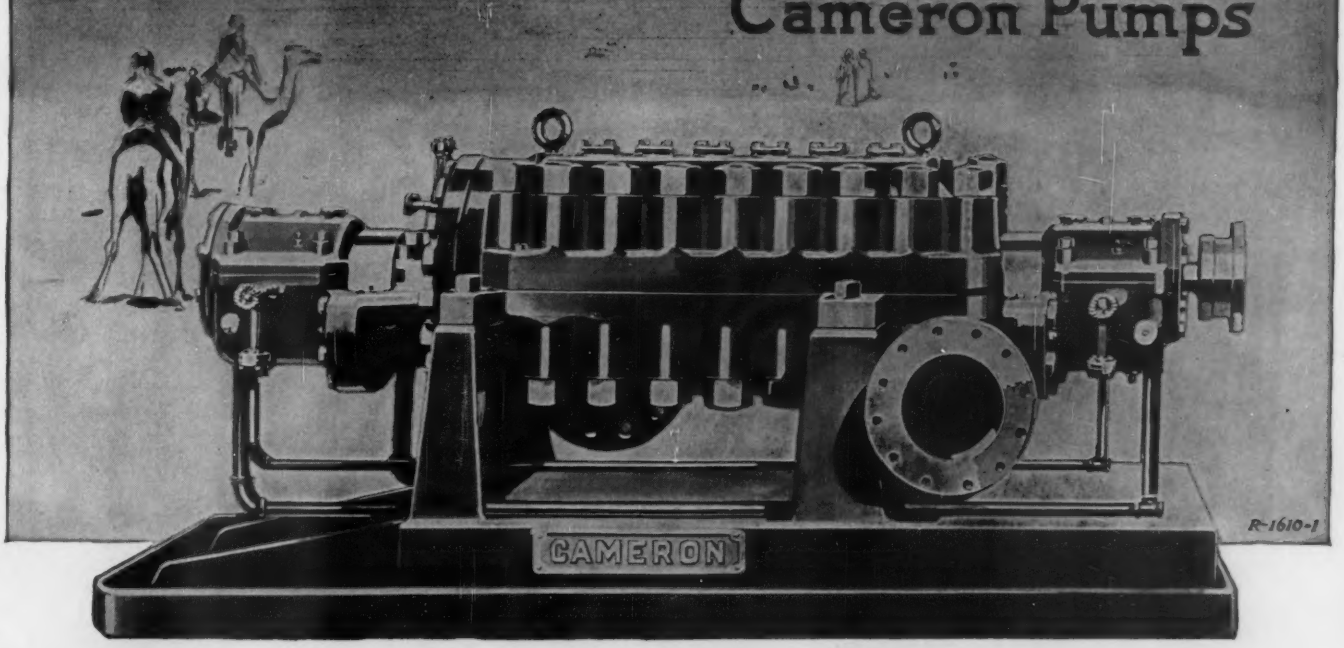
DURABILITY

Cameron Pumps are built to last.

Correct hydraulic design, conservative speeds, and comfortable margins of capacity make for smoothness and durability. And a continuing interest by the manufacturer after the pump is sold rounds out a service policy that completely protects the individual user.

Cameron Pumps are built and sold by Ingersoll-Rand Company, 11 Broadway, New York.

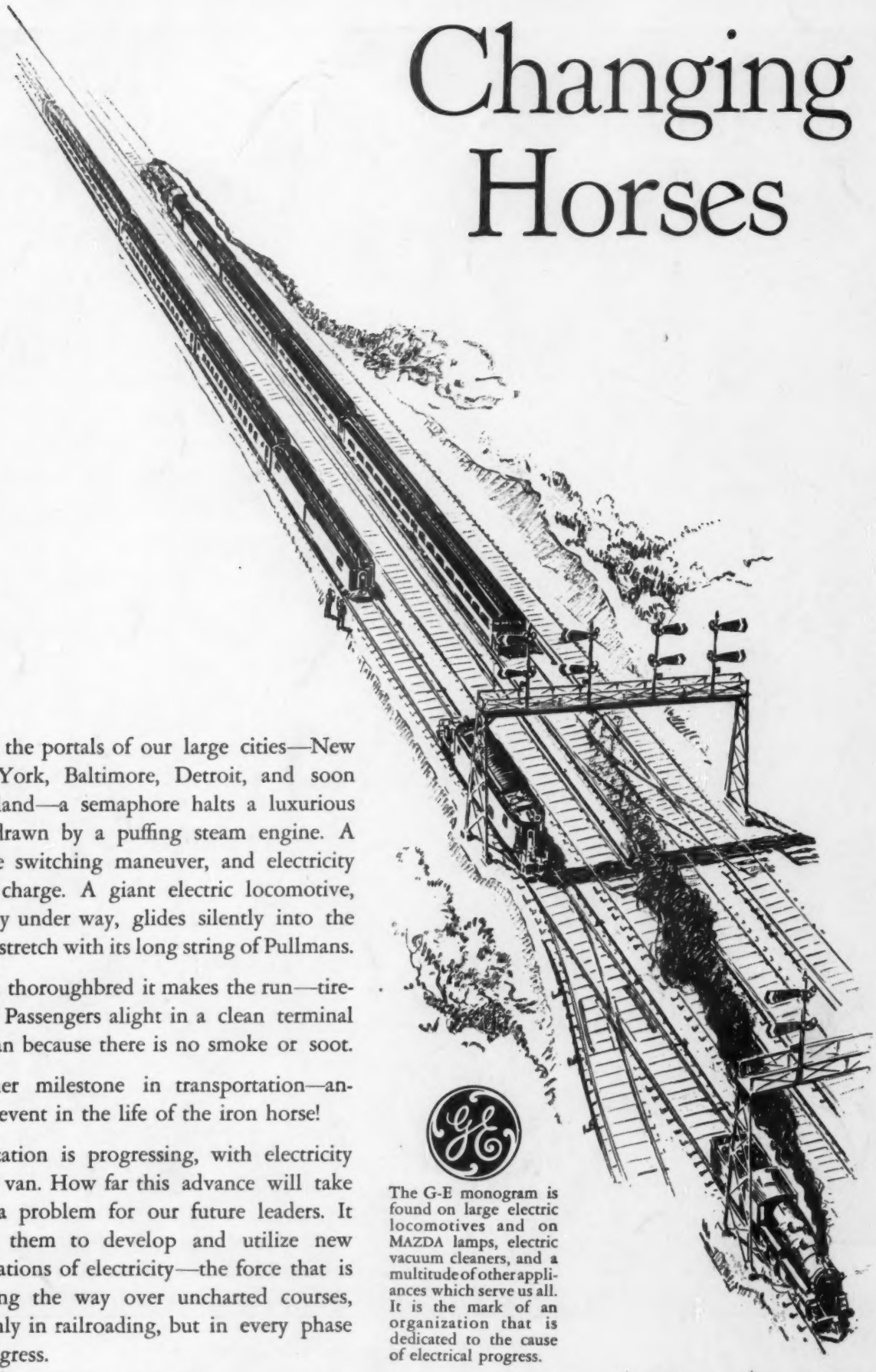
Cameron Pumps



Ingersoll-Rand

A.S. Cameron Steam Pump Works, 11 Broadway, New York—

Changing Horses



AT the portals of our large cities—New York, Baltimore, Detroit, and soon Cleveland—a semaphore halts a luxurious flyer drawn by a puffing steam engine. A simple switching maneuver, and electricity takes charge. A giant electric locomotive, quickly under way, glides silently into the home stretch with its long string of Pullmans.

Like a thoroughbred it makes the run—tirelessly. Passengers alight in a clean terminal—clean because there is no smoke or soot.

Another milestone in transportation—another event in the life of the iron horse!

Civilization is progressing, with electricity in the van. How far this advance will take us, is a problem for our future leaders. It is for them to develop and utilize new applications of electricity—the force that is pointing the way over uncharted courses, not only in railroading, but in every phase of progress.

The G-E monogram is found on large electric locomotives and on MAZDA lamps, electric vacuum cleaners, and a multitude of other appliances which serve us all. It is the mark of an organization that is dedicated to the cause of electrical progress.

95-609DH

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, NEW YORK